3.0 AFFECTED ENVIRONMENT

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH, "waters" include aquatic areas that are used by fish and their associated physical, chemical, and biological properties and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' entire life cycle.

This chapter contains descriptions of the North Pacific Ocean and the environment of the Bering Sea/Aleutian Islands, as well as the Gulf of Alaska. The descriptions focus on physical and oceanographic features, major living marine resources (their biology, habitat, and current status of the resource), and the social and economic conditions associated with the various fisheries. The BSAI and GOA ecosystems are complex. Although a lot is known, much of the vast marine ecosystem remains a mystery. A section on climatic regime shifts is provided to add insight on the long-term dynamics of the physical environment. This is important because major climatic regime shifts occurring in the North Pacific environment have affected the dynamics of living marine resources in the BSAI and GOA.

Chapter 3 also contains descriptions of the resources and issues identified by the Council as important when predicting the direct, indirect, and cumulative impacts that will accrue from the proposed action. The topics in this section are arranged in the following order: physical environment and habitat features, biological environment, ecosystem considerations, and human activities.

References to original literature throughout the section identify scientific sources and guide readers to further information. All references called out throughout this document are listed in Chapter 7. Each reference contains the information necessary to find the respective paper, report, journal article, or book, following standard library citation format. Any reader desiring to access one of the references given should be able to read or borrow a copy from a public library. Resource libraries located in Alaska and the Pacific Northwest such as the NOAA Fisheries Alaska Fisheries Science Center (AFSC) Library in Seattle, Washington; the Auke Bay Fisheries Laboratory near Juneau, Alaska; the State Library in Juneau, Alaska; and the libraries at the University of Alaska and the University of Washington will be more likely to have these particular references on their shelves. Other libraries can obtain these references through interlibrary loan systems.

3.1 Physical Environment and Habitat Features

Alaska is the largest state in the United States with a total area of 1,593,438 square kilometers (sq. km), including 70,849 sq. km of coastal water over which the state has jurisdiction and approximately 690,000 sq. km of wetlands with more than 8,000 sq. km of estuarine wetlands (low-wave energy environments) and approximately 190 sq. km of marine wetlands (high-energy wave environments). Alaska's productive marine waters include the North Pacific Ocean, Bering Sea, Chukchi Sea, and Arctic Ocean—more than 70 percent of the total area of the United States continental shelves is in Alaska. Alaska's immense size provides potential EFH from its 55,000 km of tidal shoreline, its more than 15,000 identified anadromous waterbodies, and its two major offshore marine ecosystems, the GOA and the EBS.

3.1.1 Gulf of Alaska

The GOA has approximately 160,000 sq. km of continental shelf, which is less than 25 percent of the EBS shelf. The GOA is a relatively open marine system with land masses to the east and the north. Commercial species are more diverse in the GOA than in the EBS, but less diverse than in the Washington-California region. The most diverse set of species in the GOA is the rockfish group; 30 species have been identified in this area.

The dominant circulation in the GOA (Musgrave et al. 1992) is characterized by the cyclonic flow of the Alaska gyre. The circulation consists of the eastward-flowing Subarctic Current system at approximately 50º N and the Alaska Coastal Current (Alaska Stream) system along the northern GOA. Large seasonal variations in the wind-stress curl in the GOA affect the meanders of the Alaska Stream and nearshore eddies. The variations in these nearshore flows and eddies affect much of the region’s biological variability.

The GOA has a variety of seabed types such as gravely sand, silty mud, and muddy to sandy gravel, as well as areas of hardrock (Hampton et al. 1986). Investigations of the northeast GOA shelf (less than 200 meters [m]) have been conducted between Cape Cleare (148º W) and Cape Fairweather (138º W) (Feder and Jewett 1987). The shelf in this portion of the GOA is relatively wide (up to 100 km). The dominant shelf sediment is clay silt that comes primarily from either the Copper River or the Bering and Malaspina glaciers. When the sediments enter the GOA, they are generally transported to the west. Sand predominates nearshore, especially near the Copper River and the Malaspina Glacier. Most of the western GOA shelf (west of Cape Igvak) consists of slopes characterized by marked dissection and steepness. The shelf consists of many banks and reefs with numerous coarse, clastic, or rocky bottoms, as well as patchy bottom sediments. In contrast, the shelf near Kodiak Island consists of flat relatively shallow banks cut by transverse troughs. The substrate in the area from Near Strait and close to Buldir Island, Amchitka, and Amukta Passes is mainly bedrock outcrops and coarsely fragmented sediment interspersed with sand bottoms.

Temperature anomalies in the GOA illustrate a relatively warm period in the late 1950s, followed by cooling (especially in the early 1970s), and then by a rapid temperature increase in the latter part of that decade. Subsurface temperature anomalies for the coastal GOA also show a change from the early 1970s into the 1980s, similar to that observed in the sea surface (U.S. GLOBEC 1996). In addition, high latitude temperature responses to El Niño southern oscillation events can be seen, especially at depth, in 1977, 1982, 1983, 1987, and the 1990s. Between these events, temperatures in the GOA return to cooler and more neutral temperatures. The 1997/98 El Niño southern oscillation event, one of the strongest recorded this century, has significantly changed the distribution of fish stocks off California, Oregon, Washington, and Alaska. The longer-term impacts of this event remain to be seen.

Piatt and Anderson (1996) provide evidence of possible changes in prey abundance due to decadal scale climate shifts. These authors examined relationships between significant declines in marine birds in the northern GOA during the past 20 years and found that significant declines in common murre populations occurred from the mid- to late-1970s to the early 1990s. Piatt and Anderson (1996) found marked changes in diet composition of five seabird species collected in the GOA from 1975 to 1978 and from 1988 to 1991. Their diet changed from capelin-dominated in the former period to one in which capelin was virtually absent in the latter period.

On a larger scale, evidence of biological responses to decadal-scale climate changes is also found in the coincidence of global fishery expansions or collapses of similar species complexes. For example, salmon stocks in the GOA and the California Current are out of phase. When salmon stocks do well in the GOA, they do poorly in the California Current and vice versa (Hare and Francis 1995, Mantua et al. 1997). For more information about the GOA physical environment, refer to the draft or revised draft programmatic groundfish SEIS (NMFS 2001a, 2003a).

3.1.2 Bering Sea

The Bering Sea is a semi-enclosed, high-latitude sea. Of its total area of 2.3 million sq. km, 44 percent is continental shelf, 13 percent is continental slope, and 43 percent is deep-water basin. Its broad continental shelf is one of the most biologically productive areas of the world. In contrast, the Aleutian Island shelf is very narrow. The EBS contains approximately 300 species of fish, 150 species of crustaceans and mollusks, 50 species of seabirds, and 26 species of marine mammals (Livingston and Tjelmeland 2000). However, commercial fish species diversity is lower in the EBS than in the GOA.

A special feature of the EBS is the pack ice that covers most of its eastern and northern continental shelf during winter and spring. The dominant circulation of the water begins with the passage of North Pacific water (the Alaska Stream) into the EBS through the major passes in the AI (Favorite et al. 1976). There is net water transport eastward along the north side of the AI and a turn northward at the continental shelf break and at the eastern perimeter of Bristol Bay. Eventually EBS water exits northward through the Bering Strait, or westward and south along the Russian coast, entering the western North Pacific via the Kamchatka Strait. Some resident water joins new North Pacific water entering Near Strait, which sustains a permanent cyclonic gyre around the deep basin in the central BS.

The EBS sediments are a mixture of the major grades representing the full range of potential grain sizes of mud (subgrades clay and silt), sand, and gravel. The relative composition of such constituents determines the type of sediment at any one location (Smith and McConnaughey 1999). Sand and silt are the primary components over most of the seafloor, with sand predominating the sediment in waters with a depth less than 60 m. Overall, there is often a tendency of the fraction of finer-grade sediments to increase (and average grain size to decrease) with increasing depth and distance from shore. This grading is particularly noticeable on the southeastern BS continental shelf in Bristol Bay and immediately westward. The condition occurs because settling velocity of particles decreases with particle size (Stokes Law), as does the minimum energy necessary to resuspend or tumble them. Since the kinetic energy of sea waves reaching the bottom decreases with increasing depth, terrigenous grains entering coastal shallows drift with water movement until they are deposited, according to size, at the depth at which water speed can no longer transport them. However, there is considerable fine-scale deviation from the graded pattern, especially in shallower coastal waters and offshore of major rivers, due to local variations in the effects of waves, currents, and river input (Johnson 1983).

The distribution of benthic sediment types in the EBS shelf is related to depth (Figure 3.1-1). Considerable local variability is indicated in areas along the shore of Bristol Bay and the north coast of the Alaska Peninsula, as well as west and north of Bristol Bay, especially near the Pribilof Islands. Nonetheless, there is a general pattern whereby nearshore sediments in the east and southeast on the inner shelf (0 to 50 m depth) often are sandy gravel and gravelly sand. These give way to plain sand farther offshore and west. On the middle shelf (50 to 100 m), sand gives way to muddy sand and sandy mud, which continue over much of the outer shelf (100 to 200 m) to the start of the continental slope. Sediments on the central and northeastern shelf (including Norton Sound) have not been so extensively sampled, but Sharma (1979) reports that, while sand is dominant in places here, as it is in the southeast, there are concentrations of silt both in shallow nearshore waters and in deep areas near the shelf slope. In addition, there are areas of exposed relic gravel, possibly resulting from glacial deposits. These departures from a classic seaward decrease in grain size are attributed to the large input of fluvial silt from the Yukon River and to flushing and scouring of sediment through the Bering Strait by the net northerly current.

McConnaughey and Smith (2000) and Smith and McConnaughey (1999) describe the available sediment data for the EBS shelf. These data were used to describe four habitat types. The first, situated around the shallow eastern and southern perimeter and near the Priblof Islands, has primarily sand substrates with a little gravel. The second, across the central shelf out to the 100 m contour, has mixtures of sand and mud. A third, west of a line between St. Matthew and St. Lawrence islands, has primarily mud (silt) substrates, with some mixing with sand (Figure 3.1-2). Finally, the areas north and east of St. Lawrence Island, including Norton Sound, have a complex mixture of substrates.

Important water column properties over the EBS include temperature, salinity, and density. These properties remain constant with depth in the near-surface mixed-layer, which varies from approximately 10 to 30 m in summer to approximately 30 to 60 m in winter (Reed 1984). The inner shelf (less than 50 m) is, therefore, one layer and is well mixed most of the time. On the middle shelf (50 to 100 m), a two-layer temperature and salinity structure exists because of downward mixing of wind and upward mixing due to relatively strong tidal currents (Kinder and Schumacher 1981). On the outer shelf (100 to 200 m), a three-layer temperature and salinity structure exists due to downward mixing by wind, horizontal mixing with oceanic water, and upward mixing from the bottom friction due to relatively strong tidal currents. Oceanic water structure is present year-round beyond the 200-m isobath.

Three fronts, the outer shelf, mid-shelf, and inner shelf, follow along the 200-, 100-, and 50-m bathymetric contours, respectively; thus, four separate oceanographic domains appear as bands along the broad EBS shelf. The oceanographic domains are the deep water (more than 200 m), the outer shelf (200 to 100 m), the mid-shelf (100 to 50 m), and the inner shelf (less than 50 m).

The vertical physical system also regulates the biological processes that lead to separate cycles of nutrient regeneration. The source of nutrients for the outer shelf is the deep oceanic water; for the mid-shelf, it is the shelf-bottom water. Starting in winter, surface waters across the shelf are high in nutrients. Spring surface heating stabilizes the water column, then the spring bloom begins and consumes the nutrients. Steep seasonal thermoclines over the deep EBS (30 to 50 m), the outer shelf (20 to 50 m), and the mid-shelf (10 to 50 m) restrict vertical mixing of water between the upper and lower layers. Below these seasonal thermoclines, nutrient concentrations in the outer shelf water invariably are higher than those in the deep EBS water with the same salinity. Winter values for nitrate-N/phosphate-P are similar to the summer ratios, which suggests that, even in winter, the mixing of water between the mid-shelf and the outer shelf domains is substantially restricted (Hattori and Goering 1986).

Effects of a global warming climate should be greater in the EBS than in the GOA. Located further north than the GOA, the seasonal ice cover of the EBS lowers albedo effects. Atmospheric changes that drive the speculated changes in the ocean include increases in air temperature, storm intensity, storm frequency, southerly wind, humidity, and precipitation. The increased precipitation, plus snow and ice melt, leads to an increase in freshwater runoff. The only decrease is in sea level pressure, which is associated with the northward shift in the storm track. Although the location of the maximum in the mean wind stress curl will probably shift poleward, how the curl is likely to change is unknown. The net effect of the storms is what largely determines the curl, and there is likely to be compensation between changes in storm frequency and intensity.

Ocean circulation decreases are likely to occur in the major current systems: the Alaska Stream, Near Strait Inflow, Bering Slope Current, and Kamchatka Current. Competing effects make changes in the Unimak Pass inflow, the shelf coastal current, and the Bering Strait outflow unknown. Changes in hydrography should include increases in sea level, sea surface temperature, shelf bottom temperature, and basin stratification. Decreases should occur in mixing energy and shelf break nutrient supply, while competing effects make changes in shelf stratification and eddy activity unknown. Ice extent, thickness, and brine rejection are all expected to decrease.

Temperature anomalies in the EBS illustrate a relatively warm period in the late 1950s, followed by cooling (especially in the early 1970s), and then by a rapid temperature increase in the latter part of that decade. For more information on the physical environment of the EBS, refer to the draft or revised draft programmatic groundfish SEIS (NMFS 2001a, 2003a).

3.1.3 Aleutian Islands

The Aleutian Islands lie in an arc that forms a partial geographic barrier to the exchange of northern Pacific marine waters with EBS waters. The AI continental shelf is narrow compared with the EBS shelf, ranging in width on the north and south sides of the islands from about 4 km or less to 42 to 46 km; the shelf broadens in the eastern portion of the AI arc. The AI comprises approximately 150 islands and extends about 2,260 km in length.

Bowers Ridge in the AI is a submerged geographic structure forming a ridge arc off the west-central AI. Bowers Ridge is about 550 km long and 75 to 110 km wide. The summit of the ridge lies in water approximately 150 to 200 m deep in the southern portion deepening northward to about 800 to 1,000 m at its northern edge.

The AI region has complicated mixes of substrates, including a significant proportion of hard substrates (pebbles, cobbles, boulders, and rock), but data are not available to describe the spatial distribution of these substrates.

The patterns of water density, salinity, and temperature are very similar to the GOA. Along the edge of the shelf in the Alaska Stream, a low salinity (less than 32.0 ppt) tongue-like feature protrudes westward. On the south side of the central AI, nearshore surface salinities can reach as high as 33.3 ppt, as the higher salinity EBS surface water occasionally mixes southward through the AI. Proceeding southward, a minimum of approximately 32.2 ppt is usually present over the slope in the Alaska Stream; values then rise to above 32.6 ppt in the oceanic water offshore. Whereas surface salinity increases toward the west as the source of fresh water from the land decreases, salinity values near 1,500 m decrease very slightly. Temperature values at all depths decrease toward the west.

Climate change effects on the AI area are similar to the effects described for climate change in the EBS. For more information on the physical environment of the AI, refer to the draft or revised draft programmatic groundfish SEIS (NMFS 2001a, 2003a).

3.1.4 Streams that Support Federally Managed Salmon

A significant body of information exists on the life histories and general distribution of salmon in Alaska. The locations of many freshwater water bodies used by salmon are described in documents organized and maintained by the Alaska Department of Fish & Game (ADF&G). Alaska Statute 16.05.870 requires ADF&G to specify the various streams that are important for spawning, rearing, or migration of anadromous fishes. This is accomplished through the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* (Catalog) (ADF&G 1998a) and the *Atlas to the Catalog of Waters Important for Spawning, Returning or Migration of Anadromous Fishes* (Atlas) (ADF&G 1998b). The Catalog lists water bodies documented to be used by anadromous fish. The Atlas shows locations of these waters and the species and life stages that use them. The Catalog and Atlas are divided into six volumes for the six resource management regions established in 1982 by the Joint Boards of Fisheries and Game. Additional information on streams that support federally managed salmon is available from ADF&G at http://www.state.ak.us/adfg/habitat.

3.2 Biological Environment

3.2.1 Biology, Habitat Usage, and Status of Magnuson-Stevens Act Managed Species

This section provides an overview of the biology and habitat use of FMP-managed species for which EFH must be defined. For additional information on habitat use by these species, refer to Appendix F. For additional information on the biology and population status of these resources, refer to the most recent Stock Assessment and Fishery Evaluation (SAFE) Reports for BSAI Groundfish (North Pacific Fishery Management Council [Council] 2002a), GOA Groundfish (Council 2002b), BSAI King and Tanner Crab (Council 2002c), Alaska Scallops (Council 1998), and the draft programmatic groundfish SEIS (NMFS 2001a).

This section is divided into BSAI (3.2.1.1) and GOA (3.2.1.2) species and habitat descriptions. In many cases, a more complete description is given in one section with a reference in the other; for example, Pacific cod is described at length in the BSAI section, while the GOA description of Pacific cod adds some information pertinent to GOA distribution with a reference back to the BSAI section. The reverse is true for Greenland halibut, for example. Following the BSAI and GOA sections is a section on crab species and their habitats (3.2.1.3), salmon species and their habitats (3.2.1.4), and scallops and their habitats (3.2.1.5).

3.2.1.1 GOA Groundfish

This section contains descriptions of the principal target groundfish species that may be affected by proposed fisheries management changes. Information presented for these species includes a brief description of the biology, habitat, and population status as noted in the most recent stock assessments. The information presented for each species supports the development of this SEIS and is not intended to be exhaustive.

Detailed information on groundfish species and additional information on principal target species can be found in Appendix F of this EIS and in the following documents: Environmental Assessment for EFH (Council 1999a); EFH Assessment Report for the Groundfish Resources of the BSAI Region (Council 1998a); EFH Assessment Report for the Groundfish Resources of the GOA Region (Council 1998b); the 2000 Stock Assessment and Fishery Evaluation Reports (SAFE Report) for the Groundfish Resources of the BSAI and GOA Regions (Council 2002a, 2002b); and the draft programmatic groundfish SEIS (NMFS 2001a).

3.2.1.1.1 Walleye Pollock

Pollock (*Theragra chalcogramma)* is the second most abundant groundfish stock in the GOA. It is widely distributed throughout the North Pacific Ocean in temperate and subarctic waters (Wolotira et al. 1993). Pollock is a semidemersal schooling fish, which becomes increasingly demersal with age. Approximately 50 percent of female pollock reach maturity at age 4, at a length of approximately 40 cm. Pollock spawning is pelagic and takes place in the early spring on the outer continental shelf. Pollock are comparatively short-lived, with a fairly high natural mortality rate estimated at 0.3 (Hollowed et al. 1997, Wespestad and Terry 1984) and a maximum recorded age of around 22 years. Pollock in the GOA are thought to be a single stock (Alton and Megrey 1986) originating from springtime spawning in Shelikof Strait (Brodeur and Wilson 1996).

Pollock are found throughout the water column, from the surface down to 500 m (Witherell 2000). Seasonal migrations occur from overwintering areas along the outer shelf to shallow waters (90 to 140 m) for spawning (Witherell 2000). In the GOA, major spawning concentrations of pollock have been observed in Shelikof Strait and the Shumagin Islands (DiCosimo and Kimball 2001). Major exploitable populations are found primarily in the western/central areas of the GOA (147˚ W to 170˚ W).

The diet of pollock in the EBS has been studied extensively (Dwyer 1984, Lang and Livingston 1996, Livingston 1991a, Livingston and DeReynier 1996, Livingston et al. 1993). Juvenile pollock are pelagic and feed primarily on copepods and euphausiids. As they age, pollock become increasingly piscivorous and can be highly cannibalistic. Juvenile pollock are known to be the dominant fish prey of adult pollock in the EBS. Other fish consumed by pollock include juveniles of Pacific herring, Pacific cod, arrowtooth flounder, flathead sole, rock sole, yellowfin sole, Greenland halibut, Pacific halibut, and Alaska plaice. On the shelf area, the contribution of these other fish prey to the diet of pollock tends to be very low (i.e., usually less than 2 percent by weight of the diet [Livingston 1991a, Livingston and DeReynier 1996, Livingston et al. 1993]). In the deeper slope waters, however, deep-sea fish (myctophids and bathylagids) are a relatively important diet component (12 percent by weight), along with euphausiids, pollock, pandalid shrimp, and squid (Lang and Livingston 1996).

Larvae 5 to 20 mm long consume larval and juvenile copepods and copepod eggs (Canino 1994, Kendall et al. 1987). Early juveniles (25 to 100 mm) primarily eat juvenile and adult copepods, larvaceans, and euphausiids; late juveniles (100 to 150 mm) eat mostly euphausiids, chaetognaths, amphipods, and mysids (Brodeur and Wilson 1996, Grover 1990, Krieger 1985, Livingston 1985, Merati and Brodeur 1997, Walline 1983). Juvenile and adult pollock in Southeast Alaska rely heavily on euphausiids, mysids, shrimp, and fish as prey (Clausen 1983). Euphausiids are the dominant prey of GOA pollock, making up a relatively constant proportion of the diet by weight across size classes. Shrimp and fish are the next two important prey items. Copepods are a less dominant food source (Yang 1993). Fish prey become a larger fraction of GOA pollock diet with increasing size. A high diversity of species is preyed upon. Over 20 different fish species have been identified in the stomach contents of GOA pollock, with capelin being the dominant prey (Yang 1993). Commercially important prey species include Pacific cod, pollock, arrowtooth flounder, flathead sole, Dover sole, and Greenland halibut. In addition to capelin, forage fish, including eulachon and Pacific sand lance, were also found in pollock stomach contents.

The main source of predation mortality on GOA pollock at present appears to be the arrowtooth flounder (Livingston 1994, Hollowed et al. 2000). Cannibalism is also known to be a major source of mortality in this species. Other dominant GOA groundfish populations that prey on pollock include sablefish, Pacific cod, and halibut (Albers and Anderson 1985, Best and St-Pierre 1986, Jewett 1978, Yang 1993). Pollock is one of the top five prey items (by weight) for Pacific cod, arrowtooth flounder, and halibut in this area. Other predators include great sculpins (Carlson 1995) and shortspined thornyheads (Yang 1993). In the GOA, halibut and Pacific cod tend to consume larger pollock, while arrowtooth flounder consume pollock that are mostly under age 3. Predation mortality on juvenile pollock in the GOA appears to be an increasingly controlling factor on recruitment. Before the apparent ecological regime shift of the late 1970s, environmental factors controlling larval survival appeared to be the dominant factor controlling recruitment. Since this shift, however, juvenile predation by expanding populations of predatory flatfish and cod has become the principal controlling factor.

Pollock is a major prey item for Steller sea lions and harbor seals in the GOA (Merrick and Calkins 1996; Pitcher 1980a, 1980b, and 1981). Harbor seals tend to have a more diverse diet, and the occurrence of pollock in their diet is lower than in sea lions. Pollock is a major prey item for both juvenile and adult Steller sea lions in the GOA. It appears that the proportion of animals consuming pollock increased from the 1970s to the 1980s, and this increase was most pronounced for juvenile Steller sea lions. Sizes of pollock consumed by Steller sea lions range from 5 to 56 cm, and the size composition of pollock consumed appears to be related to the size composition of the pollock population. However, juvenile Steller sea lions consume smaller pollock on average than adults. In 1985, age-1 pollock was dominant in the diet of juvenile Steller sea lions, possibly a reflection of the abundant 1984 year class of pollock available to Steller sea lions in that year.

Research on the diets of marine mammals and birds in the GOA has recently been greatly accelerated (Sections 3.2.3.1, 3.2.3.2, 3.2.3.3, 3.2.3.5, and 3.2.3.6) (Brodeur and Wilson 1996; Calkins 1987; DeGange and Sanger 1986; Hatch and Sanger 1992; Lowry et al. 1989; Merrick and Calkins 1996; Pitcher 1980a, 1980b, and 1981). The main piscivorous birds that consume pollock in the GOA are black-legged kittiwakes, common murres, thick-billed murres, tufted puffins, horned puffins, and probably marbled murrelets. The diets of common murres have been shown to contain around 5 to 15 percent age-0 pollock by weight, depending on the season. Both horned puffins and tufted puffins consume age-0 pollock (Hatch and Sanger 1992). The amount of pollock in the diet of tufted puffins varied by region in the years studied, with very low amounts in the north-central GOA and Kodiak Island areas, intermediate (5 to 20 percent) amounts in the Semidi and Shumagin islands, and large amounts (25 to 75 percent) in the Sandman Reefs and eastern AI. The proportion of juvenile pollock in the diet of tufted puffins at the Semidi Islands varied by year and was related to pollock year-class abundance.

Pollock support the largest fishery in Alaska waters. In the GOA, pollock constitute 25 to 50 percent of the catch. For 2003, the estimate of GOA pollock exploitable biomass (age 3+) was 699,000 metric tons (mt) (Figure 3.2-1). The stock is currently at low levels, but is projected to increase with recruitment of a recent large year-class.

3.2.1.1.2 Pacific Cod

Pacific cod (*Gadus macrocephalus*), also known as grey cod, are moderately fast-growing and short-lived fish. Females reach 50 percent of maturity at about 67 cm, corresponding to an age of about 6.7 years, and are highly fecund. A 67-cm female cod will produce more than 1 million eggs. Annual mortality of adults is estimated to be about 0.37 percent. Maximum age has been estimated at 18 to 19 years based on otolith samples. Estimates of natural mortality vary widely, ranging from 0.29 (Thompson and Shimada 1990) to 0.83 to 0.99 (Ketchen 1964).

In the late winter, Pacific cod converge in large spawning masses over relatively small areas. Spawning takes place in the sublittoral/bathyal zone near the bottom. In the GOA, this habitat occurs along the continental shelf and slope, between about 40 to 290 m. The eggs sink to the bottom and are somewhat adhesive (Hirschberger and Smith 1983). Optimal temperature for incubation is 3 to 6º C, optimal salinity is 13 to 23 ppt, and optimal oxygen concentration is from 2 to 3 ppm saturation. Little is known about the optimal substrate type for egg incubation.

The larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, and they move downward in the water column as they grow. Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud to clay sand.

Pacific cod is a demersal species that occurs on the continental shelf and upper slope from Santa Monica Bay, California, through the GOA, AI, and EBS to Norton Sound (Bakkala 1984). GOA, EBS, and AI cod stocks are genetically indistinguishable (Grant et al. 1987), and tagging studies show that cod migrate seasonally over large areas (Shimada and Kimura 1994). The southern limit of the species' distribution is about latitude 34º N, with a northern limit of about latitude 63º N.

In the GOA, Pacific cod are most abundant in the central area, where large schools are encountered at varying depths. Cod are concentrated on the shelf edge and the upper slope (100 to 200 m deep) in the winter and spring. These fish over-winter in this zone and spawn from January to April; then they move to shallower waters (less than 100 m deep) in the summer.

Pacific cod are omnivorous. In terms of percent occurrence, the most important food items in the GOA and BSAI are polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important items are euphausiids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important items are pollock, fishery offal, and yellowfin sole. Small Pacific cod were found to feed mostly on invertebrates, while large Pacific cod are mainly piscivorous (Livingston 1991b). Predators of Pacific cod include halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffins (Westrheim 1996).

In the GOA, the 2003 exploitable biomass (age 3+) was estimated at 452,000 mt (Figure 3.2-2). Pacific cod are considered to be at medium relative abundance, but have been declining due to recent poor year classes.

3.2.1.1.3 Yellowfin Sole

Yellowfin sole (*Limanda aspera*) are relatively slow-growing and long-lived fish. Females reach 50 percent maturity at 29 cm (about 10.5 years old) and are highly fecund, producing up to 3.5 million eggs (Nichol and Acuna 2001). Annual natural mortality of adults has been estimated at 0.12. Maximum age for this species is 31 years.

Adults are benthic and occupy separate winter and spring/summer spawning and feeding grounds. Adults overwinter near the shelf-slope break at approximately 200 m and move into nearshore spawning areas as the shelf ice recedes (Nichol 1997). Spawning is protracted and variable, beginning as early as May and continuing through August, occurring primarily in shallow water at depths less than 30 m (Wilderbuer and Nichol 2002). After spawning, adults disperse broadly over the continental shelf for feeding. Eggs, larvae, and juveniles are pelagic and are usually found in shallow areas (Nichol 1994). Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas. Adults feed mainly on bivalves, polychaetes, amphipods, and echiurids. Adults exhibit wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, and feeding diminishes during this time.

Yellowfin sole are distributed from British Columbia to the Chukchi Sea (Hart 1973). The center of their distribution is on the EBS shelf where they are managed as a single stock. In the GOA, yellowfin sole are managed with other flatfish species in the shallow water flatfish category.

3.2.1.1.4 Greenland Halibut

Greenland halibut is the name of the flatfish *Reinhardtius hippoglossoides*, commonly referred to as the Greenland turbot in North Pacific groundfish fisheries. The name "Greenland halibut" is used throughout this document. The biology, habitat use, and population information for Greenland halibut are described in Section 3.2.1.2.4, as this species is primarily distributed in the EBS and is managed as part of a larger group, deep water flatfish, in the GOA.

3.2.1.1.5 Arrowtooth Flounder

Arrowtooth flounder (*Atheresthes siomas*) are common from central California and Oregon through the EBS (Allen and Smith 1988). Arrowtooth flounder occupy continental shelf waters almost exclusively until age 4, but occupy both shelf and slope waters at older ages, with concentrations at depths between 100 and 200 m (Martin and Clausen 1995). Spawning is protracted and variable and probably occurs from September through March (Zimmermann 1997). Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs, and juveniles usually inhabit shallow areas. For female arrowtooth flounder collected off the Washington coast, the estimated age at 50 percent maturity is 5 years, with an average length of 37 cm. Males mature at 4 years and 28 cm (Rickey 1995). The natural mortality rate used in the stock assessment is 0.2 (Turnock et al. 1997b, Wilderbuer and Sample 1997). Annual natural mortality of adults has been estimated to be about 15 percent.

The habitat for the arrowtooth flounder is described in Section 3.2.1.2.5 for BSAI stocks, as the majority of the habitat usage information relates to the EBS.

In the GOA, arrowtooth flounder are the most abundant groundfish species. Exploitable biomass of arrowtooth flounder was estimated to be 1,302,000 mt in 2003 (Figure 3.2-3). Under current fishing practices in the GOA, arrowtooth flounder are often discarded when caught, although the number retained has increased from 2 percent in 1992 to 43 percent in 2000. Higher catches in recent years result from higher biomass levels, corresponding incidental catch in other target fisheries, and increased marketing efforts for arrowtooth meal and surimi (DiCosimo and Kimball 2001).

3.2.1.1.6 Rock Sole

Two species of rock sole occur in the North Pacific Ocean, a northern rock sole (*Lepidopsetta polyxstra*), and a southern rock sole (*L. bilineata*). These species have an overlapping distribution in the GOA (Turnock et al. 2002). Spawning takes place during the late winter/early spring, near the edge of the continental shelf at depths from 125 to 250 m. Eggs are demersal and adhesive (Forrester 1964). Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs. Juveniles inhabit shallow waters until at least age 1. The estimated age at 50 percent maturity for female rock sole is 7 years at a length of 33 cm (Stark and Somerton 2002). The best estimate for natural mortality is 0.20 for the GOA (Turnock et al. 1997a). The maximum age for rock sole is approximately 20 years.

Rock sole are distributed from southern California waters north into the GOA and the EBS to as far north as the Gulf of Anadyr. The distribution continues along the AI westward to the Kamchatka Peninsula, and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and in the southeastern BS (Alton and Sample 1976). Rock sole prey on benthic invertebrates such as bivalves, polychaetes, amphipods, and miscellaneous crustaceans, and, in turn, are prey for marine mammals. In the GOA, rock sole are managed as a shallow water flatfish.

3.2.1.1.7 Flathead Sole

Flathead sole (*Hippoglossus elassodon*) are distributed from northern California northward throughout Alaska (Wolotira et al. 1993). In the northern part of its range, the species overlaps with the related and very similar Bering flounder (*Hippoglossoides robustus*) (Hart 1973). Because it is difficult to separate these two species at sea, they are currently managed as a single stock (Walters and Wilderbuer 1997). Adults are benthic and have separate winter spawning and summer feeding distributions. From overwintering grounds near the continental shelf margin, adults begin a migration onto the mid- and outer-continental shelf in April or May. The spawning period occurs in the spring, primarily in deeper waters near the margins of the continental shelf (Walters and Wilderbuer 1997). Eggs are large and pelagic. Upon hatching, the larvae are planktonic and usually inhabit shallow areas (Waldron and Vinter 1978). Exact age and size at maturity are unknown, but recruitment to the fishery begins at age 3. The maximum age for flathead sole is approximately 20 years. An estimated natural mortality rate of 0.20 is used for stock assessment (Turnock et al. 1997a, Waldron and Vinter 1978).

Flathead sole range from northern California, off Point Reyes, northward along the west coast of North America and throughout the GOA and the EBS, Kurile Islands, and possibly the Okhotsk Sea (Hart 1973). Flathead sole feed primarily on invertebrates such as amphipods, ophiurids, and decapods. Adults also feed on Tanner crab, osmerids, bivalves, and polychaetes.

In the GOA, exploitable biomass for 2003 was estimated to be slightly declining (Figure 3.2-4).

3.2.1.1.8 Other Flatfish

With the exception of arrowtooth flounder, rex sole, and flathead sole, GOA flatfish are managed in two groups as “deep water flatfish” and “shallow water flatfish.” Deep water flatfish include Dover sole, Greenland halibut, and deepsea sole. Shallow water flatfish include northern and southern rock sole, yellowfin sole, starry flounder, butter sole, English sole, Alaska plaice, and sand sole. In the GOA, rex sole and flathead sole are managed separately. The exploitable biomass for rex sole for 2003 was estimated at 71,330 mt (Figure 3.2-5). Fishing for this species is constrained by halibut bycatch limits. Dover sole is the primary target species for deep water flatfish, and the estimated current biomass is 68,260 mt (Figure 3.2-6). Biomass estimates for Dover sole have a high degree of uncertainty due to the lack of deep water sampling in the triennial GOA trawl survey. The GOA 2003 exploitable biomass for shallow water flatfish was estimated at 349,990 mt (Figure 3.2-7).

3.2.1.1.9 Sablefish

Sablefish (*Anoploma fimbria*) are found in the GOA, westward to the AI, and in gullies and deep fjords generally at depths greater than 200 m such as Prince William Sound and Southeast Alaska. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). Studies have shown sablefish to be highly migratory for at least part of their life cycle (Heifetz and Fujioka 1991, Maloney and Heifetz 1997), and substantial movement has been documented between the BSAI and the GOA (Heifetz and Fujioka 1991). Thus, sablefish in Alaska waters are assessed as a single stock (Sigler et al. 1999). Adults reach maturity at 4 to 5 years and a length of 51 to 54 cm (McFarlane and Beamish 1990). Spawning is pelagic at depths of 300 to 500 m near the edges of the continental slope (McFarlane and Nagata 1988). Larvae are oceanic through the spring; by late summer, small pelagic juveniles (10 to 15 cm) have been observed along the outer coasts of Southeast Alaska, where they predominantly spend their first winter in shallow waters. While small numbers of sablefish appear on the outer shelf and upper slope at age 2, juveniles are found primarily during their first to second years in nearshore bays and during their second and third years on the continental shelf of the GOA and the EBS (Rutecki and Varosi 1997a, Umeda et al. 1983). After that, sablefish are found on the outer continental shelf and are found mainly on the slope and in deep gullies in their adult distribution. Sablefish are long-lived, with a maximum recorded age of 62 years in Alaska (Sigler et al. 1997). For stock assessments, a natural mortality rate of about 0.10 has been estimated (Sigler et al. 1999).

Sablefish are distributed from Mexico through the GOA to the EBS, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido islands and the Kamchatkan Peninsula. Larval sablefish feed on a variety of small zooplankton, ranging from copepod nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids). The older demersal juveniles and adults appear to be opportunistic feeders, with food ranging from a variety of benthic invertebrates, benthic fishes (as well as squid), mesopelagic fishes, jellyfish, and fishery discards. Feeding studies conducted in Oregon and California found that fish (mainly pollock) made up 76 percent of the diet (Laidig et al. 1997). Other studies, however, indicate a diet dominated by euphausiids (Tanasichuk 1997). Nearshore residence during their second year provides the opportunity to feed on salmon fry and smolts during the summer months. Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer. Sablefish are also prey for halibut, lingcod, seabirds, and marine mammals such as sea lions. Killer whales and sperm whales in the GOA have been known to take sablefish from longline gear as it is being retrieved. Other predators include hagfishes, sharks, and Pacific cod (GOA).

Alaska sablefish are considered a single stock and are assessed in a combined area (BSAI and GOA) with an age-structured model incorporating fishery and survey catch data and age and length compositions. Survey data come from annual sablefish longline surveys in the GOA and biennial longline surveys in the BSAI. These surveys indicate that the stock size peaked in the mid-1980s because of a series of strong years and has declined to lower levels ever since.

Recent important year classes are 1997, 1995, and 1990. Abundance has fallen in recent years because the high recruitment levels of the late 1970s have not been repeated. The dominating factor determining the age composition is the magnitude of the recruiting year classes. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of a fished population with a several-decades catch history.

In the GOA, the 2003 exploitable biomass of sablefish was estimated at 182,000 mt (Figure 3.2-8). The sablefish stock in the GOA appears low and stable, a change from previous assessments where the abundance appeared low and slowly declining. The stock cycled through two peaks in 1970 and 1985 and has decreased substantially since 1988. Exploitable and spawning biomass is projected to increase slowly in coming years.

3.2.1.1.10 Rockfish

At least 32 rockfish species of the genera *Sebastes* and *Sebastolobus* have been reported to occur in the GOA and BSAI (Eschmeyer et al. 1984), and several of them are of commercial importance. Pacific ocean perch (*Sebastes alutus*) has historically been the most abundant rockfish species in the region and has contributed most to the commercial rockfish catch. Other species such as northern rockfish (*S. polyspinis),* rougheye rockfish (*S. aleutianus*), shortraker rockfish (*S. borealis*), shortspine thornyheads (*Sebastolobus alascanus*), yelloweye rockfish (*Sebastes ruberrimus*), and dusky rockfish (*S. ciliatus*) are also important to the overall rockfish catches.

Rockfish in the GOA are currently managed as four assemblages: 1) slope rockfish, 2) pelagic shelf rockfish, 3) demersal shelf rockfish, and 4) thornyheads. Demersal shelf rockfish are a separate management assemblage found only in the eastern GOA east of longitude 140º W. Slope rockfish are those species that, as adults, inhabit waters of the outer continental shelf and continental slope generally in depths greater than 150 to 200 m. Pelagic shelf rockfish are defined as those species that inhabit waters of the continental shelf of the GOA and that typically exhibit a mid-water schooling behavior, although they can sometimes be found associated with the bottom. Demersal shelf rockfish comprises several species of shallow, nearshore bottom-dwelling rockfish. Separate ABCs, overfishing levels (OFLs), and total allowable catches (TACs) are set for each assemblage, except for slope rockfish, which are further subdivided into four subgroups with separate ABCs, OFLs, and TACs: (1) Pacific ocean perch, (2) shortraker and rougheye rockfish, (3) northern rockfish, and (4) other slope rockfish. These groups are described below.

3.2.1.1.10.1 Pacific Ocean Perch

Pacific ocean perch is primarily a demersal species that inhabits the outer continental shelf and upper continental slope regions of the North Pacific Ocean and the EBS from southern California to northern Honshu Island, Japan (Allen and Smith 1988). The species appears to be most abundant in northern British Columbia, the GOA, and the AI. As adults, they generally live on or near the seafloor at depths ranging from about 150 to 420 m.

Though more is known about the life history of Pacific ocean perch than about other rockfish species (Kendall and Lenarz 1986), much uncertainty still exists. Similar to other rockfish, Pacific ocean perch have internal fertilization and release live young (Love et al. 2002). Insemination occurs in the fall, and release of larvae occurs in April or May. Pacific ocean perch larvae are thought to be pelagic and drift with the current, but larval studies of rockfish have been hindered by difficulties in species identification. Recently, post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests that this may be the preferred habitat of this life stage. Later-stage juveniles are believed to migrate to an inshore, demersal habitat, where they seem to inhabit rockier, higher relief areas than adults (Carlson and Straty 1981; Straty 1987; Pearcy et al. 1989; Krieger 1993). As they mature, juveniles move to progressively deeper waters of the continental shelf. Large schools of juvenile Pacific ocean perch have been found on the shelf near Albatross Bank and Shumagin Bank (Westrheim 1970). Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months. Krieger (1993) noted that adult (longer than 25 cm) Pacific ocean perch are associated with pebble substrate on flat or low-relief bottom, whereas juvenile Pacific ocean perch exhibit a preference for rugged areas containing cobble-boulder and epifaunal invertebrate cover. Other studies have also shown that adult Pacific ocean perch may prefer a relatively smooth, trawlable bottom (Westrheim 1970; Matthews et al. 1989). Commercial fishing data indicate that adult Pacific ocean perch are most prevalent on the shelf break, slope, and inside major gullies and trenches running perpendicular to the shelf break (Lunsford et al. 2001).

Pacific ocean perch are a slow-growing species that, in the GOA, reach maturity at approximately 10 years, or 36 cm in length (Heifetz et al. 1997). Maximum recorded age is 84 years in the GOA and 98 years in the AI (Heifetz et al. 2002). The natural mortality rate likely is between 0.02 and 0.08 (Archibald et al. 1981, Chilton and Beamish 1982), and the midpoint of these two values (0.05) is used as the natural mortality rate in the current stock assessments for Pacific ocean perch in Alaska.

Trawl survey and commercial fishery data have consistently indicated that most of the adult population occurs in patchy, localized aggregations. Pacific ocean perch appear to exhibit an annual bathymetric migration from deep water in winter (approximately 300 to 420 m) to shallower water (approximately 150 to 300 m) in the summer and fall (Westrheim 1970). In addition, investigators in the 1960s and 1970s speculated that Pacific ocean perch sometimes inhabited the mid-water environment off-bottom. Evidence to support this conjecture has recently come from commercial fishing data in the GOA since 1995, when catches in pelagic trawls fished off-bottom have accounted for as much as 20 percent of the annual harvest of Pacific ocean perch (Heifetz et al. 2002). Separate schools of males and females have been observed on feeding grounds in Unimak Pass at depths of 150 to 185 m. Spawning concentrations have been observed at depths of 350 to 400 m off Prince William Sound and Yakutat Bay. Known spawning areas are southeast of the Pribilof Islands in the EBS and in the GOA near Yakutat. Major feeding areas are found off Unimak Pass and Kodiak and adjoining islands.

Pacific ocean perch are mostly planktivorous (Yang 1996). Small juveniles feed on calanoid copepods; large juveniles and adults feed on euphausiids, and to a lesser degree, on pandalid shrimp and squids. Predators of Pacific ocean perch are sablefish, Pacific halibut, and sperm whales (Major and Shippen 1970).

In the GOA, a foreign Pacific ocean perch fishery began in the early 1960s. This fishery developed rapidly, with massive efforts by the Soviet and Japanese fleets. Catches peaked in 1965 with landings of 350,000 mt. This apparent overfishing resulted in a precipitous decline in catches in the late 1960s. Catches continued to decline in the 1970s and early 1980s and were only 1,100 mt by 1985. Landings rose as the fishery became increasingly domestic after 1985, declined again in the early 1990s, and then increased to nearly 12,000 mt in 2002. Due to concern that the stocks of Pacific ocean perch were not recovering sufficiently from their relatively low condition, a rebuilding plan was implemented in 1995. Soon thereafter, strong year-classes contributed to increased abundance, and the stock was considered rebuilt in 1997. Pacific ocean perch is now believed to be relatively abundant, compared to its low level in the 1980s and early 1990s, and abundance appears to be increasing. The 2003 estimated biomass in the GOA is 298,820 mt (Figure 3.2-9).

3.2.1.1.10.2 Shortraker and Rougheye Rockfish

Shortraker (*Sebastes borealis*) and rougheye rockfish (*S. aleutianus*) inhabit the outer continental shelf and upper continental slope of the northeastern Pacific from the EBS as far south as Point Conception, California (Kramer and O'Connell 1988). Total exploitable biomass for this management group in the GOA in 2003 was estimated to be 66,830 mt (Figure 3.2-10). Trawl surveys have found juvenile rougheye rockfish at many inshore locations and also offshore on the continental shelf. In contrast, very few juvenile shortraker rockfish have ever been caught, and their preferred habitat is unknown. Adults of both species are semidemersal and are usually found on the continental slope in deeper waters and over rougher bottoms than Pacific ocean perch. Shortraker and rougheye adults appear together often in trawl hauls and are concentrated in a narrow band along the slope at depths of 300 to 500 m. Habitats with steep slopes and frequent boulders were used at a higher rate than those with gradual slopes and few boulders (Krieger and Ito 1999). Little is known about the biology and life history of these species, but they appear to be long-lived, with late maturation and slow growth. Shortraker rockfish have been estimated to reach ages in excess of 120 years and rougheye rockfish in excess of 140 years. Natural mortality rates have been estimated in Heifetz and Clausen (1991) at 0.025 for rougheye rockfish and 0.030 for shortraker rockfish. Like other members of the genus *Sebastes*, they are ovoviviparous (bear live young), and birth occurs in the early spring through summer (McDermott 1994).

Food habit studies conducted by Yang and Nelson (2000) indicate that the diet of rougheye rockfish is primarily shrimp and that various fish species are also consumed. The diet of shortraker rockfish is not well known; however, based on a small number of samples, the diet appears to be mostly squid, shrimp, and deepwater fish such as myctophids. Because shortraker rockfish have large mouths and short gill rakers, it is possible that they are potential predators of other fish species (Yang 1993). The main predators of both species are not known.

3.2.1.1.10.3 Northern Rockfish

Northern rockfish (*Sebastes polyspinis*) in the northeast Pacific range from the EBS, throughout the AI and the GOA, to northernmost British Columbia (Allen and Smith 1988). Little is known about the biology and life history of northern rockfish. Like other members of the genus *Sebastes*, they bear live young, and birth is believed to occur in the early spring. There is no information on larval and early juvenile biology or habitat. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat. Trawl surveys and commercial fishing data indicate that the preferred habitat of adults is on relatively shallow rises or banks on the outer continental shelf at depths of approximately 75 to 150 m (Clausen and Heifetz 2003). The fish appear to be associated with relatively rough bottoms on these banks, and they are mostly demersal in their distribution. Northern rockfish, similar to other rockfish, are long-lived and slow-growing. Maximum age determined is 44 years for the GOA and 72 years for the AI; natural mortality rate for the GOA is estimated to be 0.06.

Northern rockfish are generally planktivorous (feed on plankton) with euphausiids being the predominant prey item in both the GOA and the AI (Yang 1993, 1996). Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities. Predators of northern rockfish are not well documented, but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species.

Although northern rockfish are lower in value than Pacific ocean perch, they have supported a valuable directed trawl fishery in the GOA since at least 1990. In this region, the northern rockfish fishery was separated from the slope rockfish fishery in 1993 to prevent overfishing. Biomass for northern rockfish in the GOA is estimated to be 108,830 mt for 2003 (Figure 3.2-11). Due to poor recruitment in recent years, population modeling suggests that abundance may decline in future years, but there is relative uncertainty in the biomass estimates, catch history, and life history parameters for this species.

3.2.1.1.10.4 Other Slope Rockfish Species

Numerous other rockfish species of the genus *Sebastes* have been reported in the GOA and BSAI (Eschmeyer et al. 1984), and several are of commercial and ecological importance. Most are demersal or semidemersal, with different species occupying different depth strata (Kramer and O'Connell 1988). In common with all rockfish, they have internal fertilization and release live young (Love et al. 2002). Little or nothing is known concerning life history attributes of most of these rockfish in Alaska waters. Because they are long-lived and slow growing, natural mortality rates are probably low (less than 0.10). There is no information on food habits for any of the other slope rockfish species in Alaska, although some of the more common, smaller species such as sharpchin, harlequin, and redstripe rockfish appear to be planktivores. Other slope rockfish species are taken primarily as bycatch in trawl and longline fisheries.

In the GOA, although the other slope rockfish management group comprises 17 species, 6 species alone make up 95 percent of the catch and estimated abundance: sharpchin (*Sebastes zacentrus*), redstripe (*S. proriger*), harlequin (*S. variegatus*), yellowmouth (*S. reedi*), silvergrey (*S. brevispinis*), and redbanded rockfish (*S. babcocki*).

3.2.1.1.10.5 Pelagic Shelf Rockfish

In the GOA, pelagic shelf rockfish consist of dusky rockfish (*Sebastes ciliatus*), yellowtail rockfish (*S. flavidus*), and widow rockfish (*S. entomelas*). Genetic and morphometric studies indicate that two distinct species of dusky rockfish occur in the North Pacific Ocean: an inshore, shallow water, darkcolored variety and a lighter-colored variety found offshore (Clausen et al. 2002). These two species are presently being described in a formal taxonomic paper. Black rockfish were formerly in the pelagic shelf group, but they were removed from both the group and the GOA groundfish Fishery Management Plan (FMP) in April 1998. Light dusky rockfish is by far the most important species in the group, both in terms of abundance and commercial value. Life history information on light dusky rockfish is extremely sparse. Females give birth to live young apparently in the spring, but there is no information on the larval or early juvenile stages. Older juveniles have not been sampled in large numbers, but appear to live on the continental shelf, generally at locations inshore of adults. Catches of adults are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf at depths of 100 to 149 m (Reuter 1999), indicating that this is their preferred habitat. Although light dusky rockfish are classified into the pelagic shelf group, this may be inappropriate, as the fish are commonly taken by bottom trawl. The other three species in the group appear to be more pelagic in their distribution. Light dusky rockfish have an estimated natural mortality rate of 0.09, an indication that this species is faster-growing and shorter-lived than most other rockfish. The maximum age for dusky rockfish is 59 years.

Trophic interactions of dusky rockfish are not well known. Food habit information is available from just one study, with a relatively small sample size for dusky rockfish (Yang 1993). This study indicated that adult dusky rockfish consume primarily euphausiids, followed by larvaceans, cephalopods, and pandalid shrimp. Predators of dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth flounder.

The estimated exploitable biomass for pelagic shelf rockfish in the GOA for 2003 is 62,500 mt (Figure 3.2-12). Based on trawl surveys, light dusky rockfish recruitment is a relatively infrequent event. Biomass estimates since 1988 show a population peak of 83,000 mt in the late 1980s, followed by low population levels of 30,000 mt from 1990 to 1992, and then an increase in population between 1993 and 1998. However, none of these changes appears to be statistically significant, and the actual trend in abundance for this complex is unknown.

3.2.1.1.10.6 Demersal Shelf Rockfish

Demersal shelf rockfish include seven species of nearshore, bottom-dwelling rockfish: canary rockfish (*Sebastes pinniger)*, China rockfish (*S. nebulosus)*, copper rockfish (*S. caurinus)*, quillback rockfish (*S. maliger)*, rosethorn rockfish (*S. helvomaculatus)*, tiger rockfish (*S. nigrocinctus)*, and yelloweye rockfish (*S. ruberrimus*). The Council manages demersal shelf rockfish as a distinct assemblage only off the Southeast Outside District (SEO), an area that is further divided into four management units along the outer coast: the south SEO (SSEO), central SEO (CSEO), north SEO (NSEO), and East Yakutat (EYKT). Yelloweye rockfish comprise 90 percent of the catch and are the focus of this section.

Yelloweye rockfish occur on the continental shelf from northern Baja California to the EBS, commonly in depths less than 200 m (Kramer and O'Connell 1988). They are long-lived, slow-growing, and late-maturing. Yelloweye have been estimated to reach an age of 118 years, and their natural mortality rate is estimated at 0.02 (O'Connell and Funk 1987). They are ovoviviparous (live bearing) with parturition (birth) occurring primarily in late spring through midsummer (O'Connell 1987). Yelloweye inhabit areas of rugged, rocky relief, and adults appear to prefer complex bottoms with "refuge spaces" (O'Connell and Carlile 1993). Demersal shelf rockfish are highly valued, and a directed longline fishery is held for these species. However, yelloweye are also taken as bycatch in the halibut fishery; therefore, a large portion of the TAC and ABC are set aside for bycatch. In 1998, 31 percent of the total demersal shelf rockfish landings occurred as bycatch in the halibut fishery (O'Connell et al. 1999).

Yelloweye are large, predatory fishes that usually feed close to the bottom. Food habit studies indicate that the diet of yelloweye rockfish is dominated by fish remains, which comprised 95 percent, by volume, of the stomach contents analyzed. Herring, sand lance, and Puget Sound rockfish (*S. emphaeus*) were particularly dominant. Shrimp are also an important prey item (Rosenthal et al. 1988).

Demersal shelf rockfish have been landed incidental to other groundfish and halibut fisheries since the early 1900s. Some bycatch was also landed by foreign longline and trawl vessels targeting slope rockfish in the eastern GOA from the 1960s through the mid-1970s. Beginning in 1979, a small, primarily nearshore-based, rockfish fishery began in Southeast Alaska, targeting the nearshore, bottom-dwelling component of the rockfish complex. The demersal shelf rockfish catch increased from 106 mt in 1982 to a peak of 901 mt in 1993 and decreased back down to 282 mt in 2000. Directed fishery landings have been constrained by other fishery management actions (DiCosimo and Kimball 2001). In the GOA, the 2003 estimated biomass for demersal shelf rockfish is 17,510 mt (Figure 3.2-13).

3.2.1.1.10.7 Thornyheads

Thornyheads in Alaska waters comprise two species: the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). Only the shortspine thornyhead is of commercial importance. It is a demersal species found in deep water, from 93 m to 1,460 m, from the EBS to Baja California (Ianelli and Gaichas 1999). The longspine thornyhead inhabit depths from 370 to 1,600 m. Little is known about thornyhead life history. Like other rockfish, they are long-lived and slow growing. The maximum recorded age is probably in excess of 50 years, and females do not become sexually mature until an average age of 12 to 13 and a length of about 21 cm. Thornyheads spawn large masses of buoyant eggs during the late winter and early spring (Pearcy 1962). Juveniles are pelagic for the first year.

Thornyhead rockfish inhabit the outer shelf and slope region throughout the northeastern Pacific and EBS. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the GOA, while cottids were the most important prey item in the AI.

The 2003 estimated exploitable biomass for thornyheads was 85,760 mt (Figure 3.2-14). Assuming average recruitment when fished, thornyheads are expected to decline. The abundance of this complex is relatively high. Due to the long-lived nature of this species, the overall harvest rate recommendations have been about 4 percent of the total age 5+ (exploitable) biomass.

3.2.1.1.11 Atka Mackerel

The biology and general habitat use for Atka mackerel are discussed in Section 3.2.1.2.11, BSAI Groundfish. In the GOA, an estimate of exploitable biomass has not been available since 1996 due to extreme survey-catch variances. Atka mackerel are considered to be at a low level of relative abundance. The Atka mackerel fishery has been managed as a bycatch-only fishery since 1997, with very low TACs intended to provide bycatch for other directed fisheries. There may be some evidence of localized depletion; this species has exhibited vulnerability to fishing pressure in the past. The dramatic decline of the Atka mackerel fishery in the GOA suggests that the area may be the edge of the species' range and may be populated only when recruitment, possibly as juveniles, from the AI portion of the range is strong.

In the GOA, the Atka mackerel population existed primarily in the Kodiak, Chirikof, and Shumagin areas and supported a targeted foreign fishery in the 1970s through the early 1980s. Catches peaked in 1975 at about 27,000 mt and dropped to almost nothing in 1986. All landings since then have been taken by the domestic fishery.

3.2.1.2 BSAI Groundfish

3.2.1.2.1 Walleye Pollock

Walleye pollock (*Theragra chalcogramma*) are the most abundant fish species within the EBS. The biology of walleye pollock is described in Section 3.2.1.1.1. Although the stock structure of EBS pollock is not well defined (Wespestad 1993), three pollock stocks are recognized in the BSAI for management purposes: EBS, AI, and Aleutian Basin stocks. The general habitat use of walleye pollock is described in the GOA groundfish section. In the EBS, the largest concentrations occur in the southeast, north of Unimak Pass.

Various studies have modeled pollock cannibalism and other sources of predation, particularly in the EBS (Dwyer 1984; Honkalehto 1989; Knechtel and Bledsoe 1981, 1983; Laevastu and Larkins 1981; Livingston 1991b, 1993, 1994; Livingston et al. 1993; Livingston and DeRenyier 1996; Wespestad and Dawson 1992). Early efforts treated cannibalism in either a static or a dynamic fashion. Trends in recent efforts have used more standard stock assessment procedures such as virtual population analysis or integrated statistical catch-at-age models (Methot 1990). The following features summarize the effects of cannibalism and other factors affecting pollock recruitment and population dynamics:

- Cannibalism is the largest source of juvenile predation and is apparently responsible for observed declines in recruitment at high levels of pollock spawning biomass.
- In the current state of the EBS, cannibalism appears to be the most important source of predation mortality for age-0 and age-1 pollock.
- Predation mortality rates are not constant, varying over time with changes in predator abundance.
- Surface currents during pollock's early life stages may be an important factor in juvenile pollock survival due to differential food availability and predation levels.
- The pollock population trend experiences a high degree of year-class variability. However, the level of catches appears to result in relatively conservative harvest rates (approximately 15 percent per year) that are reasonably sustainable.

While cannibalism is the significant source of juvenile mortality in the EBS, several other groundfish predators are also important consumers. Other predators of juvenile pollock include arrowtooth flounder, Pacific cod, halibut, and flathead sole (Livingston 1991b, Livingston and DeReynier 1996, Livingston et al. 1993). These species are some of the more abundant groundfish in the EBS, and pollock constitute a large proportion of their diets. Other less abundant species that consume pollock include Greenland halibut, Alaska skate, sablefish, Pacific sandfish, various sculpins, and small-mouthed flounders such as yellowfin sole and rock sole (Livingston 1989, Livingston et al. 1993, Livingston and DeReynier 1996). Age-0 and age-1 pollock are the targets of most of these predators, but Pacific cod, halibut, and Alaska skate may consume pollock ranging from age 0 to greater than age 6.

Pollock is a significant prey item for Steller sea lions and for other species of marine mammals in the EBS. Studies suggest that pollock is a primary prey item of northern fur seals when feeding on the shelf during summer (Sinclair et al. 1997, 1994). The pollock consumed by fur seals are primarily age-0 and age-1 fish. Older age groups of pollock may appear in the diet when young pollock are less abundant (Sinclair et al. 1997). Pollock have been noted as a prey item for other pinnipeds, including harbor seals, spotted seals, and ribbon seals. Harbor seals tend to have a variable diet, and the pollock component varies with abundance. Spotted and ribbon seals feed on pollock in the winter and spring in the areas of drifting ice, and pollock are their most common prey during these seasons (Lowry et al. 1997). Fin, minke, and humpback whales in the EBS are also known to be pollock predators. Stomach samples from the whale species have been very limited, so the importance of pollock in their diets has not been well-defined (Kajimura and Fowler 1984).

In the EBS, age-0 and age-1 pollock are variably the dominant component in the diets of northern fulmars, black-legged kittiwakes, common murres, and thick-billed murres. Red-legged kittiwakes also consume pollock, but tend to rely more heavily on myctophids (Hunt et al. 1981, Kajimura and Fowler 1984, Springer et al. 1986). These species are the dominant avifauna of the EBS (Kajimura and Fowler 1984, Shuntov 1993). Fluctuations in kittiwakes' chick production have been linked to the availability of fatty fishes, such as myctophids, capelin, and Pacific sand lance (Hunt et al. 1995). Changes in the availability of prey, including pollock, for surface-feeding seabirds may be due to changes in sea surface temperatures and the locations of oceanographic features such as fronts, which could influence the horizontal or vertical distribution of prey (Decker et al. 1995, Springer 1992).

Pollock support the largest fishery in Alaska waters. In the BSAI, pollock comprise 75 to 80 percent of the total annual catch. In the BSAI for 2003, the exploitable biomass in the EBS was projected at 11.1 million mt (Figure 3.2-15). The stock has increased and stabilized due to recruitment of a strong 1996 year-class and a series of average ones thereafter.

3.2.1.2.2 Pacific Cod

Pacific cod is a demersal species that occurs on the continental shelf and upper slope from Santa Monica Bay, California, through the GOA, AI, and EBS to Norton Sound (Bakkala 1984). The EBS represents the center of greatest abundance, although Pacific cod are also abundant in the GOA and AI. Major spawning aggregations occur between Unalaska and Unimak islands, southwest of the Pribilof Islands, and near the Shumagin group in the western GOA (Shimada and Kimura 1994). The general habitat use of Pacific cod is described in the GOA groundfish section.

In the BSAI, the exploitable biomass was estimated at 1,680,000 mt for 2003 (Figure 3.2-16). The stock has declined for several years due to poor year class production, but it appears to have stablized.

3.2.1.2.3 Yellowfin Sole

In the EBS, yellowfin sole is the most abundant flatfish species and is the target of the largest flatfish fishery in the United States. The biology of the yellowfin sole is described in the section on GOA groundfish. Information specific to the EBS is presented in this section. Spawning occurs in June and July in the shallow waters of Bristol Bay to Nunivak Island. Adults exhibit summertime spawning and feeding on sandy substrates of the EBS shelf. Widespread distribution occurs mainly on the middle and inner portion of the shelf. Yellowfin sole feed primarily on benthic invertebrates, with polychaetes, amphipods, decapods, and clams dominating the diet in the EBS (Livingston 1993).

For 2003, in the BSAI, exploitable biomass is projected to be 1.55 million mt (Figure 3.2-17). The stock has recently been at high levels, and abundance peaked in 1985 due to good recruitment in the early 1970s and low exploitation. Biomass has declined 1 mt since the peak in 1985 and is projected to remain stable or continue a slow decline in the near future.

Yellowfin sole stocks were overexploited by foreign fisheries from 1959 to 1962. Since that time, indices of relative abundance showed major increases during the late 1970s. Since 1981, while abundance has fluctuated widely, biomass estimates indicate that the population remains high and stable.

Information on yellowfin sole stock conditions in the BSAI comes primarily from the annual EBS trawl survey. Estimates of yellowfin sole biomass derived from these surveys have been more variable than would be expected for a comparatively long-lived and lightly exploited species (Wilderbuer 1997). Nichol (1997) hypothesized that much of the yellowfin sole resource is found at depths less than 30 m during the summer when bottom trawl surveys are conducted. In a recent assessment, Wilderbuer and Nichol (2002) modeled a linear relationship between annual survey abundance estimates and bottom water temperature. Results suggested that the timing of the spawning migration may be temperature related, which could cause the survey to underestimate the abundance of yellowfin sole in cold years when a larger portion of the stock is inshore.

3.2.1.2.4 Greenland Halibut

Greenland halibut (*Rienhardtius hippoglossoides*) are a relatively fast growing species. Females reach 50 percent maturity at approximately 60 cm (approximately 9 years old) and produce 60,000 to 80,000 eggs. Spawning occurs in winter, may be protracted (starting as early as September and continuing until March) (Bulatov 1983), and is located in the eastern Bering Sea slope. The eggs are benthypelagic (suspended in the water column near the bottom) (D'yakov 1982). The larvae are planktonic for up to 9 months until metamorphosis occurs, usually with a widespread distribution through shallow waters. Juveniles are believed to spend the first 3 or 4 years of life on the continental shelf, then move to the continental slope as adults (Alton et al. 1988, Templeman 1973). Greenland halibut are demersal to semipelagic. Adults inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. Greenland halibut are a moderately long-lived species, with a maximum recorded age of 21 years (Ianelli and Wilderbuer 1995) and an estimated natural mortality rate of 0.18 (Ianelli et al. 1997).

Greenland halibut (*Reinhardtius hippoglossoides*) are distributed from Baja California northward throughout Alaska, although they are rare south of Alaska and are primarily distributed in the eastern BSAI (Hubbs and Wilimovsky 1964). Greenland halibut have an amphiboreal distribution, occurring in the North Atlantic and North Pacific, but not in the intervening Arctic Ocean. In the North Pacific, species abundance is centered primarily in the EBS and, secondarily, in the Aleutians. On the Asian side, they occur in the Gulf of Anadyr along the EBS coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shvetsov 1978). Juveniles are absent in the AI, suggesting that populations in that area originate elsewhere, and have been found on the northern part of the EBS shelf in summer trawl surveys (Alton et al. 1988).

Juveniles feed primarily on euphausiids, polychaetes, and small walleye pollock. Pelagic fish are the main prey of adult Greenland halibut, with pollock often a major species in the diet (Livingston 1991b). Greenland halibut also feed on squid, euphausiids, and shrimp. Predators include Pacific cod, pollock, and yellowfin sole.

Exploitable biomass of Greenland halibut in the BSAI was projected at 112,000 mt for 2003 (Figure 3.2-18). The stock biomass peaked in the early 1970s, followed by a persistent decline in current population levels due to poor recruitment. Biomass is projected to remain low in the foreseeable future due to small year-classes produced in the 1980s and 1990s.

3.2.1.2.5 Arrowtooth Flounder

The biology of the arrowtooth flounder is discussed in GOA Section 3.2.1.1.5. The very similar Kamchatka flounder (*Atheresthes evermanni*) also occurs in the EBS. Because it is not usually distinguished from arrowtooth flounder in commercial catches, both species are managed as a group. Values of 50 percent maturity for the EBS stock are 42.2 cm and 46.9 cm for males and females, respectively (Zimmerman 1997). The maximum reported ages are 16 years in the EBS and 18 years in the AI. Arrowtooth flounder are very important as a large, aggressive, and abundant predator of other groundfish species. Predators include Pacific cod and pollock, mostly preying on small fish.

Arrowtooth flounder occupy separate winter and summer distributions on the EBS shelf. From over-wintering grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and outer shelf in April or May each year with the onset of warmer water temperatures. Larvae have been found over a widespread area of the EBS shelf in April and May, and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Juveniles remain in shallow areas until they reach the 10 to 15 cm range.

Exploitable biomass of BSAI arrowtooth flounder was projected to be 597,000 mt for 2003 (Figure 3.2-19). The huge increases in biomass seen in the 1990s resulted from strong year-classes produced from 1980 to 1989. The stock is expected to decline slightly in the future, as recent year classes have been average or below average.

3.2.1.2.6 Rock Sole

Two species of rock sole occur in the North Pacific, a northern rock sole (*Lepidopsetta polyxstra*), and a southern rock sole (*L. bilineata*). The northern species primarily comprise the BSAI populations, where they are managed as a single stock (Wilderbuer and Walters 1997). General biology of rock sole is described in Section 3.2.1.1.6. Information specific to the EBS is presented in this section. Adults are benthic and, in the EBS, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Adults spend the summertime on the sandy substrates of the EBS shelf. Distribution is widespread on the middle and inner portion of the shelf. In winter, adults migrate to deeper waters of the shelf margin for spawning and to avoid extremely cold temperatures. Feeding diminishes during this time. The best estimate for natural mortality is 0.18 for the BSAI (Wilderbuer and Walters 1992).

General habitat requirements for rock sole are discussed in the GOA groundfish section; information specific to the EBS is presented in this section. Rock sole spawning in the eastern and western BS was found to occur at depths from 125 to 250 m, close to the shelf/slope break. Rock sole are abundant on the EBS shelf and, to a lesser extent, in the AI. Rock sole occur throughout the continental shelf (less than 250 m deep) and are particularly abundant in the Bristol Bay area during the summer. Spawning concentrations occur north of Unimak Island at the mouth of Bristol Bay and east of the Pribilof Islands (Shubnikov and Lisovenko 1964).

Exploitable biomass for rock sole was projected to be 887,000 mt for 2003 (Figure 3.2-20). Biomass in the 1990s increased due to strong year-classes produced from 1980 to 1987 and in 1990. The stock is expected to decline in the future, as recent year-classes have been below average. Recent catches have remained stable at approximately 30,000 to 60,000 mt per year.

3.2.1.2.7 Flathead Sole

The general biology and habitat use of flathead sole is described in Section 3.2.1.1.7. Information specific to the EBS is included in this section. In the northern part of its range, the species overlaps with the related and very similar Bering flounder (*Hippoglossoides robustus*) (Hart 1973). Because it is difficult to separate these two species at sea, they are currently managed as a single stock (Walters and Wilderbuer 1997). In the EBS, fish species represented 5 to 25 percent of the diet (Livingston et al. 1993). Predators include Pacific cod, Pacific halibut, arrowtooth flounder, and also cannibalism by large flathead sole, mostly on fish less than 20 cm standard length.

Exploitable biomass in the BSAI for flathead sole was projected at 550,000 mt for 2003 (Figure 3.2-21). The increase in biomass in the 1980s and 1990s resulted from strong year-classes produced from 1977 to 1987. The stock is expected to decline in the future as recent year-classes have been average to below average. Recent catch levels are indicative of increased bycatch rates in other fisheries (corresponding to higher biomass) and developing markets (Witherell 2000).

3.2.1.2.8 Other Flatfish

In the EBS, eight other flatfish species are managed under the FMPs: Alaska plaice (*Pleuronectes quadriterculatus*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*), butter sole (*Isopsetta isolepis*), sand sole (*Psettichthys melanostictus*), and deepsea sole (*Embassichthys bathybius*). Although less is known regarding these species, adults of all species are benthic and are believed to occupy separate winter spawning and summer feeding grounds. Adults overwinter in deeper water and move into nearshore spawning areas in the late winter and spring. Spawning takes place as early as November for Dover sole (Hagerman 1952) but occurs from February through April for most species (Hart 1973). Most flatfish eggs are pelagic and sink to the bottom shortly before hatching (Alderdice and Forrester 1968, Hagerman 1952, Orcutt 1950, Zhang 1987), except for butter sole, which has demersal eggs (Levings 1968).

In the EBS, Alaska plaice is the most abundant and commercially important of the other flatfish species. In 2002, it was removed from the "Other Flatfish" management group and is managed as a separate stock. It is a comparatively long-lived species and has frequently had an assessed age as high as 25 years. For stock assessment purposes, a natural mortality rate of 0.25 is used (Wilderbuer and Walters 1997). Spawning takes place on hard sandy ground, usually in March or April (Zhang 1987), in deeper waters of the shelf margin. The eggs and larvae are pelagic and transparent and have been found in icthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf. Larvae are planktonic for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow waters. Little is known of the feeding habits, spawning, growth characteristics, seasonal movements, population age, or size structure for the other seven species in the BSAI other flatfish management category.

Alaska plaice inhabit continental shelf waters in the North Pacific, ranging from the GOA to the Bering and Chukchi seas and in Asian waters as far south as Peter the Great Bay (Pertseva-Ostroumova 1961, Quast and Hall 1972). From overwintering grounds near the shelf margins, adults begin a migration, primarily less than 100 m, onto the central and northern shelf of the EBS. Alaska plaice appear to feed primarily on polychaetes, marine worms, amphipods, and echiurids (Livingston and DeReynier 1996, Livingston et al. 1993). Predators include Pacific halibut (Novikov 1964), yellowfin sole, beluga whales, and fur seals (Salveson 1976).

Exploitable biomass (age 4+) of Alaska plaice in the BSAI was projected to be 107,000 mt for 2003. It is expected that the stock will remain stable in the near future. Aging data have indicated a series of strong year classes increased biomass to a peak in the mid-1980s, and the biomass has been at average levels since.

3.2.1.2.9 Sablefish

The general biology and the habitat use of sablefish are discussed in GOA Groundfish, Section 3.2.1.1.9. Exploitable biomass was projected to be 31,000 mt in the EBS and 39,000 in the AI for 2003 (Figure 3.2-22). The stock had declined due to low recruitment from 1982 through the mid-1990s, but appears to have stabilized at a low biomass level.

3.2.1.2.10 Rockfish

General information on rockfish is discussed in Section 3.2.1.1.10. Information specific to the BSAI is included in this section. BSAI Pacific ocean perch and northern rockfish are each managed as a single species in the BSAI area, whereas shortraker rockfish and rougheye rockfish are managed in a species complex with a combined OFL level. Other rockfish includes all *Sebastes* and *Sebastolobus* species in the BSAI other than Pacific ocean perch, northern rockfish, shortraker rockfish, and rougheye rockfish. Shortspine thornyheads account for more than 90 percent of the estimated biomass of the other rockfish assemblage in the BSAI.

3.2.1.2.10.1 Pacific Ocean Perch

The general biology and habitat use of Pacific ocean perch is described in the GOA groundfish section. In the BSAI, 2003 exploitable biomass of Pacific ocean perch was projected to be 374,000 mt (Figure 3.2-23). Several above average year-classes were produced during the 1980s in the AI area, which increased the stock somewhat in this area. In the EBS, catches peaked in 1961 (47,000 mt); in the AI, catches peaked in 1965 (109,000 mt). Stocks and catches declined, reaching their lowest levels in the mid-1980s. Joint-venture fisheries of the 1980s were replaced by the domestic fleet by 1990. Since then, catches have been 8,000 to 20,000 mt per year.

3.2.1.2.10.2 Shortraker and Rougheye Rockfish

Information on the general biology, population status, and habitat use of shortraker and rougheye rockfish is discussed in the GOA groundfish section. In the AI, combined catches of shortraker and rougheye rockfish have ranged from 441 to 1,130 mt from 1993 to 2002. In the EBS, the catch of shortraker and rougheye rockfish was 42 mt and 104 mt during 2001 and 2002, respectively; prior to 2001, the catches of EBS shortraker and rougheye rockfish were combined with northern and sharpchin rockfish. Harvest limits for shortraker and rougheye rockfish are determined by multiplying an exploitation rate by a recent estimate of stock size, which is obtained from bottom trawl surveys in the BSAI region. Average shortraker and rougheye estimates from the AI trawl surveys from 1991, 1994, 1997, 2000, and 2002 were 11,480 mt for shortraker rockfish and 27,317 mt for rougheye rockfish. An EBS slope survey was recently initiated, and it produced 2002 biomass estimates of 565 mt and 1,463 mt for rougheye and shortraker rockfish, respectively.

3.2.1.2.10.3 Northern Rockfish

Information on the general biology and habitat use of northern rockfish is discussed in the GOA groundfish section. The catch of northern rockfish from the EBS and AI regions in 2002 was 112 mt and 3,601 mt, respectively. Much of the catch of northern rockfish in the AI region occurs as bycatch in the Atka mackerel fishery, leading to high discard rates. Harvest limits for northern rockfish are determined by multiplying an exploitation rate by a recent estimate of stock size, which is obtained from bottom trawl surveys in the BSAI region. An average of northern rockfish biomass estimates from the 1991, 1994, 1997, 2000, and 2002 AI trawl surveys is 155,000 mt. An EBS slope survey was recently initiated and produced a 2002 biomass estimate of 33 mt for northern rockfish.

3.2.1.2.10.4 Other Rockfish Species

Numerous other rockfish species of the genus *Sebastes* have been reported in the GOA and BSAI (Eschmeyer et al. 1984), and several are of commercial importance. Most are demersal or semidemersal, with different species occupying different depth strata (Kramer and O'Connell 1988). All are viviparous (Hart 1973). Little or nothing is known concerning life history attributes of most of these rockfish. Because they are long-lived and slow-growing, natural mortality rates are probably low (less than 0.10). The diet of species for which such information exists seems to consist primarily of planktonic invertebrates (Yang 1993 and 1996). Other rockfish species are taken both in directed fisheries and as bycatch in trawl and longline fisheries.

In the BSAI, the 2001 estimated exploitable biomass of other rockfish for 2003 was 18,000 mt in the EBS and 15,000 mt in the AI. Historically, the peak catch for other rockfish in the EBS occurred in 1978 with the removal of 2,600 mt. In the AI region, peak catch occurred in 1979 with the harvest of 4,500 mt. Catches in more recent years have been lower and mainly incidental to other deepwater fisheries (Witherell 2000).

3.2.1.2.11 Atka Mackerel

Atka mackerel (*Pleuogrammus monopterygius)* are one of the most abundant groundfish species in the AI, where they are the target of a directed trawl fishery (Lowe and Fritz 1999). Adults are semipelagic and spend most of the year over the continental shelf in depths generally less than 200 m. Adults migrate annually to shallow coastal waters during spawning, forming dense aggregations near the bottom (Morris 1981, Musienko 1970). In Russian waters, spawning peaks in mid-June (Zolotov 1993) and from July through October in Alaska waters (McDermott and Lowe 1997). Females deposit adhesive eggs in nests or rocky crevices. The nests are guarded by males until hatching occurs (Zolotov 1993). The first *in situ* observations of spawning habitat in Seguam Pass were documented in August 1999 (Lauth, R., personal communication, NMFS Alaska Fisheries Science Center). Atka mackerel nests, nest-guarding males, and spawning females were observed and verified with underwater video and self-contained underwater breathing apparatus (SCUBA) diving operations. Planktonic larvae are found up to 800 km from shore, usually in the upper water column, but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in the fishery and in surveys. Nichol and Somerton (2002) examined the diurnal vertical migrations of Atka mackerel using archival tags and related these movements to light intensity and current velocity. Atka mackerel displayed strong diel behavior, with vertical movements away from the bottom occurring almost exclusively during daylight hours and little to no movement at night. Genetic studies indicate that Atka mackerel form a single stock in Alaska waters (Lowe et al. 1998). However, growth rates can vary extensively among different areas (Kimura and Ronholt 1988, Lowe et al. 1998, Lowe and Fritz 1999). Differences in growth rates consistently observed throughout their Alaska range are believed to be phenotypic characteristics reflecting differences in the local environment. Age and size at 50 percent maturity have been estimated at 3.6 years and 33 to 38 cm, respectively (McDermott and Lowe 1997). Atka mackerel are a relatively short-lived groundfish species. A maximum age of 15 years has been noted; however, most of the population is probably less than 10 years old. The current assumed value of natural mortality is 0.3, which is consistent with values of natural mortality derived from methods that do not rely on growth parameters, which vary according to area (Lowe and Fritz 1999).

Atka mackerel are distributed from the east coast of the Kamchatka Peninsula, throughout the AI and the EBS, and eastward through the GOA to Southeast Alaska (Wolotira et al. 1993). Their current center of abundance is in the AI, with marginal distributions extending into the southern BS and the western GOA (Lowe and Fritz 1999).

Atka mackerel are an important component in the diet of other commercial groundfish, mainly arrowtooth flounder, Pacific halibut, and Pacific cod; seabirds, mainly tufted puffins and thick billed murres; and marine mammals, mainly northern fur seals and Steller sea lions (Byrd et al. 1992, Livingston et al. 1993, Fritz et al. 1995, Sinclair and Zeppelin 2002, Yang 1996). Atka mackerel are also components in the diets of the following marine mammals and seabirds: harbor seals, Dall's porpoise, thick-billed murres, and horned puffins (Yang 1996). The diets of commercially important groundfish species in the AI during the summer of 1991 were analyzed by Yang (1996). More than 90 percent of the total stomach content (by weight) of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. Euphausiids (mainly *Thysanoessa inermis* and *T. rachii*) were the most important prey items, followed by calanoid copepods. The two species of euphausiids comprised 55 percent of the total stomach contents, and copepods comprised 17 percent. Larvaceans and hyperiid amphipods had high frequencies of occurrence (81 percent and 68 percent, respectively), but comprised less than 8 percent of the total stomach content weight. Squid was another item in the diet of Atka mackerel; it had a frequency of occurrence of 31 percent, but comprised only 8 percent of total stomach content. Atka mackerel are known to eat their own eggs. Yang (1996) found that Atka mackerel eggs comprised 3 percent of the total stomach content and occurred in 9 percent of the analyzed Atka mackerel stomachs. Pollock were the second most important prey fish of Atka mackerel, comprising about 2 percent of the total stomach content. Myctophids, bathylagids, zoarcids, cottids, stichaeids, and pleuronectids were minor components of the Atka mackerel diet; each category comprised less than 1 percent of the total stomach content.

For 2003, the exploitable biomass of Atka mackerel in the AI was projected at 358,000 mt (Figure 3.2-24). Biomass of Atka mackerel increased during the late 1970s and early 1980s and again in the early 1990s. The stock has shown a declining trend in biomass since 1991 which ended in 2000, after which the stock showed a large increase in biomass in 2001, bolstered by a very strong 1998 year class. The assessment model estimates above average (greater than 20 percent of the mean) recruitment from the 1977, 1986, 1988, 1992, 1995, and 1998 year classes. The 1998 year class is estimated to be the third largest year class in the time series, after the 1977 and 1988 year classes. The most recent assessment indicates a downward trend in abundance after 2001, although it appears stable at this time.

3.2.1.3 BSAI King and Tanner Crabs

An estimated 70 percent of the invertebrate epifaunal biomass in the EBS consists of red king crab (*Paralithodes camtschatica*); blue king crab (*P. platypus*); golden king crab (*Lithodes aequispina*); scarlet king crab (*L. couesi*); opilio Tanner crab (*Chionoecetes opilio)*, also called snow crab; bairdi Tanner crab ©*. bairdi)*; grooved Tanner crab ©*. tanneri);* triangle Tanner crab ©*. angulatus*); and four species of sea stars. The mean invertebrate epifaunal biomass in the southeastern BS is 4.1 grams per square meter (g/sq. m). In the southeastern BS, echinoderms, especially *Asteria amurensis*, represent 84.4 percent (1.6 g/sq. m) of the epifauna biomass in water less than 40 m deep. In 40 to 100 m of water, *A. amurensis* represents 12.7 percent (0.6 g/sq. m), the largest component of the biomass with the exception of red king crab and opilio Tanner crab. The largest component of the invertebrate epifaunal biomass in water deeper than 100 m in the southeastern BS other than crabs of the genus *Chionoecetes* or *Paralithodes* is a basket star, *Gorgonocephalus caryi*, representing 7.3 percent (0.4 g/sq. m) (Jewett and Feder 1981).

King and Tanner crabs share a similar life cycle, although particular life cycle traits are distinct for each species. After males and females mate, the female carries the eggs for approximately 1 year, at which time the eggs hatch into free-swimming larvae. After drifting with the currents and tides and undergoing several development changes, the larvae settle to the ocean bottom and molt into nonswimmers, looking very much like miniature adult crabs. The juvenile crabs settle on preferred habitat, where they continue to molt and grow for several years until they become sexually mature. Each life stage for BSAI crab stocks is concentrated at some combination of depth, habitat, geographic area, and time of year.

In the trophic structure, crabs are members of the inshore benthic infauna consumers guild (Council 1994). During each life stage, crab consume different prey and are consumed by different predators. Planktonic larval crab consume phytoplankton and zooplankton and are prey for pelagic fish, such as salmon and herring. Post-settlement juveniles feed on diatoms, protozoa, hydroids, crabs, and other benthic organisms. Food eaten by king crabs varies with size, depth inhabited, and species, but includes a wide assortment of worms, clams, mussels, snails, brittle stars, sea stars, sea urchins, sand dollars, barnacles, fish parts, and algae. King crabs fall prey to a wide variety of species, including Pacific cod, rock sole, yellowfin sole, pollock, octopus, and other king crab (Livingston et al. 1993). Bairdi and opilio Tanner crabs feed on an extensive variety of benthic organisms, including bivalves, brittle stars, other crustaceans, polychaetes and other worms, gastropods, and fish (Lovrich and Sainte-Marie 1997). In turn, they are consumed by a wide variety of predators, including groundfish, bearded seals, sea otters, octopus, Pacific cod, halibut and other flatfish, eelpouts, and sculpins (Tyler and Kruse 1997). Opilio Tanner crab comprise a large portion of the diet of many skate species (Orlov 1998). Different king and Tanner crab species and their distribution in the North Pacific are described in the following sections.

3.2.1.3.1 Red King Crabs

Red king crabs are widely distributed throughout the BSAI, GOA, Sea of Okhotsk, and along the Kamchatka shelf up to depths of 250 m. King crabs molt several times per year through age 3 and annually thereafter. At larger sizes, king crabs may skip molt as growth slows. Females grow more slowly and do not get as large as males. In Bristol Bay, males attain 50 percent maturity at 120-mm carapace length and females at 90-mm carapace length (about 7 years). Mean age at recruitment into the fishery is 8 to 9 years. Natural mortality of adult king crabs is estimated at 0.2. Red king crabs in Norton Sound mature at smaller sizes and do not attain the maximum sizes found in other areas. In Bristol Bay, red king crabs mate when they enter shallower waters (less than 50 m), generally beginning in January and continuing through June. Males grasp females just prior to female molting, after which the eggs (43,000 to 500,000 eggs) are fertilized and extruded on the female's abdomen. The females carry the eggs for 11 months before they hatch, generally in April. Red king crabs spend 2 to 3 months in larval stages before settling to the benthic life stage. Young-of-the-year crabs occur at depths less than 50 m. They are solitary and need high-relief habitat or coarse substrate, such as boulders, cobble, shell hash, and living substrates, such as bryozoans and stalked ascidians (Stevens and Kittaka 1998). At 1.5 to 2 years, crabs form pods consisting of thousands of crabs and migrate to deeper water. Podding generally continues until 4 years (about 65 mm), when the crabs join adults in the spring migration to shallow water for spawning and the summer/fall feeding migration to deep water.

Egg hatch of larvae is synchronized with the spring phytoplankton bloom in Southeast Alaska, suggesting temporal sensitivity in the transition from benthic to planktonic habitat. EFH of the red king crab egg stage is based on the general distribution and habitat-related density of egg-bearing red king crabs in Bristol Bay, Pribilof Islands, Norton Sound, and Dutch Harbor stocks.

Red king crabs spend 2 to 3 months in pelagic larval stages before settling to the benthic life stage. Reverse diel migration and feeding patterns of larvae coincide with the distribution of food sources.

Shallow nearshore areas (less than 50 m deep) provide important structural habitat for early juvenile instars of red king crab (Sundberg and Clausen 1977). Early juvenile instars are cryptic and occupy the protective refuges provided by high-relief habitat or coarse substrate, such as boulders, cobble, and shell hash, and living substrates (macroalgae, bryozoans, stalked ascidians, etc.) (Sundberg and Clausen 1977). Adult red king crabs also use highly structured shallow water habitat during the mating period and will use macroalgae as cover during this period (Stone et al. 1993).

Early-juvenile-stage red king crab are solitary and need high-relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Young-of-the-year crabs occur at depths of 50 m or less. EFH for early juveniles is currently defined for Bristol Bay red king crabs as the general distribution. No EFH is defined for red king crab early juveniles in the Pribilof Islands, Norton Sound, Dutch Harbor, and Adak stocks.

Late juvenile stage red king crabs exhibit deceasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Podding generally continues until 4 years of age, when the crabs move to deeper water to join adults in the spring migration.

Mature red king crabs exhibit seasonal migration to shallow waters for reproduction. The reminder of the year, red king crabs are found in deep waters. In Bristol Bay, red king crabs mate when they enter shallower waters (less than 50 m), generally beginning in January and continuing through June. The female carries the eggs for 11 months before they hatch, generally in April.

Pacific cod is the main predator on red king crabs. Walleye pollock, yellowfin sole, and Pacific halibut are minor consumers of pelagic larvae, settling larvae, and larger crabs, respectively. Juvenile crabs are cannibalistic during molting.

The Bristol Bay red king crab stock remains stable, but at relatively low levels compared to past abundance levels (pre-1980). Survey and fishery data indicate a recent strong increase of Pribilof Islands red king crab, however. The combined red and blue king crab Pribilof Islands fishery was closed in 1999, and the red king crab fishery has not reopened due to bycatch concerns for blue king crabs.

3.2.1.3.2 Blue King Crabs

Blue king crabs are distributed discontinuously throughout their range (Hokkaido, Japan, to Southeast Alaska). In the EBS, discrete populations exist around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island. Smaller populations have been found around Nunivak and King islands. Adult male blue king crabs occur at an average depth of 70 m and an average water temperature of 0.6º C. Blue king crabs molt multiple times as juveniles. Skip molting occurs with increasing probability for males larger than 100-mm carapace length. In the Pribilof Islands, males attain 50 percent maturity at 108-mm carapace length and females attain 50 percent maturity at 96-mm carapace length (about 5 years) (Somerton and MacIntosh 1983). Blue king crabs in the St. Matthew Island area mature at smaller sizes (50 percent maturity at 77-mm carapace length for males and 81-mm carapace length for females) and do not get as large overall. Blue king crabs have a biennial ovarian cycle and a 14-month embryonic period before hatching in late spring.

Crabs depend on specific habitat types throughout their life stages. Larvae of blue king crab spend 3.5 to 4 months in pelagic larval stages before settling to the benthic life stage. Larvae are found in waters between 40 and 60 m deep. Settlement on habitat with adequate shelter, food, and temperature is imperative to the survival of first settling crab. Young-of-the-year red and blue king crabs require nearshore shallow habitat with significant protective cover (e.g., sea stars, anemones, microalgae, shell hash, cobble, shale) (Stevens and Kittaka 1998).

Late juvenile blue king crabs require nearshore rocky habitat with shell hash. EFH is currently based on general distribution and density of late juvenile king crabs of the Pribilof Islands stock. General distribution of late juvenile king crabs is used to identify EFH for the St. Matthew Island stock. Information is not available to define EFH for the St. Lawrence Island stock of late juvenile blue king crab. Unlike red king crabs, juvenile blue king crabs do not form pods, but instead rely on cryptic coloration for protection from predators.

Mature blue king crabs occur most often between 45 and 75 m on mud-sand substrate next to gravel rocky bottom areas. Female crabs are often found in habitat with a high percentage of shell hash. Mating occurs in mid-spring. Larger, older females reproduce biennially, while small females tend to reproduce annually. Fecundity of females ranges from 50,000 to 200,000 eggs per female. Spawning may depend on the availability of nearshore rocky-cobble substrate for protection of females. Larger, older crabs disperse farther offshore and are thought to migrate inshore for molting and mating.

The blue king crab populations in the EBS are at very low levels. The 2002 NMFS survey estimated legal male abundance in the Pribilof Islands to be below the minimum stock size threshold, and they were, thus, declared overfished. The Council is currently preparing a rebuilding plan for this stock. The St. Matthew Island and Pribilof Island blue king crab stocks were estimated to be below the minimum stock size threshold and they were, thus, declared overfished. The fishery for each is currently closed, and 10-year rebuilding plans are being developed and implemented.

3.2.1.3.3 Golden King Crabs

Golden king crabs, also called brown king crabs, range from Japan to British Columbia. In the BSAI, golden king crabs are found at depths from 200 to 1,000 m, generally in high-relief habitat such as inter-island passes. Size at sexual maturity depends on latitude, with crabs in the northern areas maturing at smaller sizes. In the St. Matthew Island area, males attain 50 percent maturity at 92-mm carapace length and females at 98-mm carapace length. In the Pribilof Islands and western AI, males attain 50 percent maturity at 107-mm carapace length and females at 100-mm carapace length. Further south, in the eastern AI, males attain 50 percent maturity at 130-mm carapace length and females at 111-mm carapace length.

General distribution and density of egg-bearing female golden king crabs are currently used to identify EFH for the Sequam Pass stock. EFH for the egg life stage of the Adak and Pribilof islands stocks is based on general distribution of the egg bearing female crabs. Late juvenile golden king crabs are found throughout the depth range of the species. Abundance of late juvenile crab increases with depth, and these crabs are most abundant at depths less than 548 m.

Mature golden king crabs occur at all depths within their distribution. Males tend to congregate in somewhat shallower areas than females, and this segregation appears to be maintained throughout the year. Legal male crabs are most abundant between 274 and 639 m. Abundance of sub-legal males increases at depths of less than 364 m. Female abundance is greatest at intermediate depths between 274 and 364 m.

ADF&G and NMFS do not make annual abundance estimates for EBS golden king crabs, and commercial harvest is allowed by ADF&G permit (Morrison et al. 1998). Catches have declined from the early years of the fishery, as the initial stock was exploited, and recruitment was unable to sustain the fishery at its initial harvest levels (Morrison et al. 1998). In 1995, the State of Alaska mandated observer coverage for all vessels targeting golden king crabs in the AI.

3.2.1.3.4 Scarlet King Crabs

Scarlet king crabs are found in the BSAI areas. Little information is available on their biology. Based on data from the GOA, this species occurs in deep water, primarily on the continental slope. Spawning may be asynchronous. Females may produce up to 5,000 eggs. Information to define EFH for eggs, larvae, and early and late juveniles is currently not available for the EBS, Adak, or Dutch Harbor stocks. EFH for mature scarlet king crabs is currently based on the general distribution of mature golden king crabs. Mature scarlet king crabs are caught incidentally in the golden king crab fisheries.

3.2.1.3.5 Tanner Crabs

Tanner crabs are distributed on the continental shelf of the North Pacific Ocean and EBS from Kamchatka to Oregon. Off Alaska, Tanner crabs are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula and are found in lower abundance in the GOA. After molting many times as juveniles, Tanner crabs reach sexual maturity at about age 6 with an average carapace width of 110 to 115 mm for males and 80 to 110 mm for females (Tyler and Kruse 1997). At maturity, most males undergo terminal molt; however, some may molt after maturity (Zheng et al. 1998). Male Tanner crabs reach a maximum size of 190-mm carapace width and live up to 14 years (Donaldson et al. 1981). Males of commercial size usually range between 7 and 11 years old and vary in weight from 1 to 2 kg (Adams 1979). Natural mortality of adult Tanner crabs is estimated at 0.3. Tanner crab females are known to form high-density mating aggregations, or pods, consisting of hundreds of crabs per mound. These mounds may provide protection from predators and attract males for mating. Research shows the female Tanner crabs prefer mating with large, old-shell males (Paul and Paul 1996, Paul et al. 1995). Mating occurs from January through June. Some females can retain viable sperm in spermathecae for up to 2 years. Females carry clutches of 50,000 to 400,000 eggs for 1 year after fertilization. Hatching occurs between April and June (Tyler and Kruse 1997).

Larvae of Tanner crabs are typically found in the BSAI water column from 1 to 100 m in early summer. They are strong swimmers and perform diel migrations in the water column. They usually stay near the depth of the chlorophyll maximum during the day. The last larval stage settles onto the bottom mud. EFH of Tanner crab larvae is currently based on general distribution for the Bristol Bay and Pribilof Islands stocks. Information is currently not available to define EFH for larval Tanner crab in the eastern Aleutian and western Aleutian stocks. Early juvenile Tanner crabs occur from 10 to 20 m in mud habitat in summer and are known to burrow and associate with many types of cover (Tyler and Kruse 1997). Late juvenile Tanner crab migrate offshore of their early nursery habitat.

Mature Tanner crabs migrate inshore, and mating is known to occur February through June. Mating need not occur every year, as female Tanner crabs can retain viable sperm in spermathecae up to 2 or more years. Females carry clutches of 50,000 to 400,000 eggs and nurture the embryos for 1 year after fertilization. Primiparous females may carry the fertilized eggs for as long as 1.5 years. Brooding occurs 100 to 150 m deep.

The EBS Tanner crab fishery has remained closed in 1997, 1998, and 1999 due to low abundance. The 1998 survey abundance estimates for large males (135-mm carapace width) and large females are the lowest on record for the survey (NMFS 1998c). Most legal males encountered were in the eastern district, with the highest abundance in central Bristol Bay. The cohort, which began recruiting into the fishery from 1988 to 1992, has declined as a result of natural mortality and fishery removals. During the

1997 survey, 95 percent of legal males encountered were old-shelled and not expected to molt again, and few young males in the 50- to 115-mm carapace width range were surveyed. Given these two factors, it is likely that the EBS Tanner crab population will continue to decline for years (Morrison et al. 1998). Council considers the stock overfished, and a rebuilding plan has been implemented.

3.2.1.3.6 Opilio Tanner Crabs

Opilio Tanner crabs are distributed on the continental shelf of the EBS, the Arctic Ocean, and in the western Atlantic Ocean as far south as Maine. Opilio Tanner crabs are not present in the GOA. In the EBS, they are common at depths of no more than 200 m. The EBS population within United States waters is managed as a single stock; however, the distribution of the population extends into Russian waters to an unknown degree. Opilio Tanner crabs reach sexual maturity at age 4, with an average carapace width of 65 mm for males and 50 mm for females. The mean size of mature females varies from year to year from 63-mm to 72-mm carapace width. Females cease growing with a terminal molt upon reaching maturity, and they rarely exceed 80-mm carapace width. Males similarly cease growing upon reaching a terminal molt when they acquire the large claw characteristic of maturity. Male opilio Tanner crabs reach a maximum size of 150-mm carapace width and live up to 14 years. Large, hard-shelled males out-compete adolescent and small adults in mating with females (Sainte-Marie et al. 1997). Commercial-size males usually range between 7 and 11 years old and vary in weight from 0.5 to 1 kg (Adams 1979). Female opilio Tanner crabs are able to store spermatophores in seminal vesicles and fertilize subsequent egg clutches without mating. At least two groups of eggs can be fertilized from stored spermatophores, but the frequency of this occurring in nature is not known (Sainte-Marie et al. 1997).

A geographic cline in size of opilio Tanner crabs indicates that a large number of morphometrically immature crabs occur in shallow waters less than 80 m. EFH is based on the general distribution and density of juvenile crabs of the EBS stock.

Female opilio Tanner crabs are acknowledged to attain terminal molt status at maturity. Primiparous female snow crabs mate January through June and may exhibit a longer egg development period and lower fecundity than multiparous female crabs. Females carry clutches of about 36,000 eggs and nurture the embryos for about 1 year after fertilization. However, fecundity may decrease up to 50 percent between the time of egg extrusion and hatching, presumable due to predation, parasitism, abrasion, or decay of unfertilized eggs. Brooding probably occurs in depths greater than 50 m. Changes in the proportion of morphometrically mature crabs by carapace width have been related to an interaction between cohort size and depth.

Large male opilio Tanner crabs were estimated at 94 million crabs in 1999, a decline of 63 percent from 1998. The mature biomass declined below the minimum stock size threshold of 460 million pounds, and the stock was declared overfished July 18, 2003 (NMFS 1999b). A rebuilding plan has been implemented for this stock. A harvest of 33.5 million pounds was landed in 2000, based on a reduced harvest rate from past years. Little recruitment is apparent from recent surveys.

3.2.1.3.7 Grooved Tanner Crabs

In the eastern North Pacific Ocean, the grooved Tanner crab ranges from northern Mexico to Kamchatka. Little information is available on the biology of the grooved Tanner crab. This species occurs in deep water and is not common at depths less than 300 m. Male and female crabs are found at similar depths and generally reach maturity at 11.9 and 7.9 cm carapace width, respectively.

In the EBS, mature male grooved Tanner crabs may be found in somewhat more shallow water than females, but males and females do not show clear segregation by depth.

3.2.1.3.8 Triangle Tanner Crabs

In the eastern North Pacific Ocean, the distribution of triangle Tanner crabs ranges from Oregon to the Sea of Okhotsk. This species occurs on the continental slope in waters less than 300 m deep and has been reported as deep as 2,974 m in the EBS. A survey found that mature male crabs typically inhabit shallower depths than the females.

The mean depth of mature male triangle Tanner crabs (647 m) is significantly less than that for mature females (748 m), indicating some patterns of sexual segregation by depth. General distribution of mature triangle Tanner crabs is used to identify EFH of the Bristol Bay and Eastern Aleutian Island stocks.

3.2.1.4 Scallops

Weathervane scallops (*Pantinopectin caurinus*) are distributed from Point Reyes, California, to the Pribilof Islands, Alaska. The highest known densities in Alaska are found in the EBS, near Kodiak Island, and in the eastern GOA from Cape Spencer to Cape St. Elias. Weathervane scallops are found from intertidal waters to depths of 300 m, but abundance tends to be highest at depths from 40 to 130 m on silt, sand, and gravel substrates (Hennick 1973). Beds tend to be elongated along the direction of current flow. Weathervane scallops are capable of swimming, but typically reside in depressions they form in the seafloor. A combination of large-scale processes (overall spawning population size and oceanographic conditions) and small-scale processes (site suitability for settlement) influence the recruitment of scallops to beds. Sexes are separate and mature male and female scallops can be distinguished by gonad color. Weathervane scallops mature after 3 years in Alaska and spawn from May to July, depending on latitude and depth. Eggs and spermatozoa are released into the water where fertilization occurs. Larvae are pelagic and drift for about 1 month until metamorphosis to the juvenile stage. They then settle to the seafloor.

Several other species of scallops found in the Exclusive Economic Zone (EEZ) of Alaska have commercial potential. These species do not attain the large size of weathervane scallops and, thus, have not been commercially exploited in Alaska. Pink scallops, *Chlamys rubida*, range from California to the Pribilof Islands. Pink scallops are found from approximately 10 to 1,600 m deep on sand, gravel, and bedrock. Pink scallops mature at age 2 and spawn during winter (January to March). Maximum age for pink scallops is 6 years, and the average size is 70 mm. Spiny scallops, *Chlamys hastata*, are found in coastal regions from California to the GOA. They generally occur in shallower areas than *C. rubida* (to approximately 150 m), and prefer a rocky substrate with strong currents. Spiny scallops grow to a larger size than *C. rubida* (90 mm). Spiny scallops mature at age 2 and spawn in the fall (August to October). Rock scallops, *Crassadoma gigantea,* range from Baja California to Unalaska Island. Rock scallops are found in relatively shallow water (0 to 60 m) with strong currents. The distribution of this species is discontinuous, and abundance in most areas is low. Juveniles are free-swimming, but become attached to rocks after about 6 months. Rock scallops are thought to spawn during two distinct periods: during the fall (October to January) and in the spring and summer (March to August).

Scallops are found in the same benthic habitat as non-economically important fish and invertebrate species. Non-commercial fishes include sharks, sculpins, and many species of small fishes. Macro-invertebrates not commercially harvested include several species of crabs and shrimps, snails, clams, tunicates, bryozoans, sea urchins, seastars, sea anemones, sponges, and corals.

Few major predators of Alaska scallop species have been identified, especially during the planktonic and juvenile stages, but they likely include many species of fishes and invertebrates. The rose star, *Crossaster papposus*, is a major predator of *C. rubida* (Carlson and Pfister 1999). Other scallop species are preyed upon by sea stars, crabs, and anemones.

Catch data for Alaska scallops is shown in Figure 3.2-25. Recent catches have been stable at about 800,000 pounds per year as a result of management actions to limit access, control harvests, and minimize crab bycatch.

3.2.1.5 Salmon

Five species of Pacific salmon, pink *(Oncorhynchus gorbuscha)*, chum *(O. keta)*, sockeye *(O. nerka)*, coho *(O. kisutch)*, and chinook salmon *(O. tshawytscha)*, as well as steelhead trout (*O. mykiss*), occur in Alaska. With some important variations, all species have a similar appearance and anadromous life history. Salmonids spawn in fresh water, their eggs hatch and go through several developmental stages in fresh water until they out-migrate to the ocean as fry or smolts. The young salmon feed and grow to maturity, ranging widely over the North Pacific Ocean, EBS, and Chukchi Sea. They return to fresh water, often migrating tremendous distances to reach their natal streams, where they spawn and then die. This adaptation to spawning in fresh water has resulted in the tremendous seasonal abundance of spawning salmon, relatively easily harvested, and sustaining large human populations for millennia. Adult salmon do not compete directly with juveniles for the relatively scarce food resources found in freshwater environments. Carcasses left in the streams after spawning fertilize the fresh water and riparian environment, ultimately providing food for the developing young.

Information on salmon distribution in Alaska is available in the ADF&G Catalog (ADF&G 1998a) and the Atlas (ADF&G 1998b). These documents, however, were derived from USGS maps that may now be out of date, do not accurately depict areas where the number of streams was very dense, and were based on stream survey observations of the upper limit of stream use, rather than on the actual limits of anadromous fish.

Alaska commercial salmon harvests generally increased over the last three decades, but may have peaked in 1995. After reaching record low catch levels in the 1970s, most populations have rebounded, and fisheries are now at or near all-time peak levels in many regions of the state (Burger and Wertheimer 1995, Wertheimer 1997). The record-high commercial landing of 217 million salmon in 1995 was 11 percent higher than the previous record of 196 million in 1994. Significant declines in the commercial catches have, however, followed in both 1996 and 1997. The 1998 Alaska commercial salmon harvest of 151 million salmon (322,055 mt) was distributed as 22.6 million sockeye (57,607 mt), 18.9 million chum (73,937 mt), 105 million pink (169,646 mt), 4.6 million coho (16,284 mt), and 563 thousand chinook (4,581 mt). Recreational fishermen caught over 1.8 million salmon in Alaska in 1995 (Howe et al. 1996). Subsistence fisheries for salmon in 1994, the most recent year available, harvested over 1 million fish (Council 1998a).

All five species of Alaska salmon are fully utilized, and stocks in most regions of the state generally have rebuilt to or beyond previous high levels. The unprecedented high abundance of Alaska salmon up to 1995 should not be interpreted as an absence of some of the same factors affecting declines of salmon in the Pacific Northwest. Issues and problems associated with salmon management include the potential for overfishing, bycatch in other fisheries, and destruction or loss of freshwater spawning and rearing habitats, as well as important nearshore marine habitats.

A number of factors have contributed to the current high abundance of Alaska salmon. These include 1) an abundance of pristine habitats with minimal impacts from extensive development, 2) favorable ocean conditions that allow high survival of juveniles, 3) improved management of the fisheries by state and federal agencies, 4) elimination of high-seas driftnet fisheries by foreign nations, 5) hatchery production, and 6) reduction of bycatch in fisheries for other species. Unspoiled habitats, favorable oceanic conditions, and adequate numbers of spawning salmon are likely the paramount issues affecting current Alaska salmon abundance. Alaska salmon management continues to focus on maintaining pristine habitats and ensuring adequate escapements. Ocean conditions, however, that have favored high marine survivals in recent years, fluctuate due to interdecadal climate oscillations (Mantua et al. 1997). Recent evidence exists that a change in ocean conditions in the North Pacific Ocean and GOA may be underway, possibly reflecting the downturn in abundance of Alaska salmon runs in 1996 and 1997.

3.2.1.5.1 Pink Salmon

Pink salmon occur from northern California to Russia and Korea; and are the most common species in Alaska. The natural fresh water range of pink salmon includes the Pacific rim of Asia and North America north of about longitude 40º N. Within this vast area, spawning pink salmon are widely distributed in coastal streams of both continents. In marine environments along both the Asian and the North American coastlines, pink salmon occupy ocean waters south of the limits of spawning streams.

Pink salmon have a fixed, 2-year life span and migrate to sea soon after the fry emerge from the gravel in spring. Maturing males develop a marked hump. They are also the smallest species; adults average 1.6 to 2 kg with an average length of 50 to 65 cm. In Alaska, adult pink salmon enter spawning steams between June and mid-October. Most pink salmon spawn within a few miles of the coast, and spawning within the intertidal zone or near the stream mouth is very common. In general, pink salmon select spawning sites in gravel where the stream bed gradient increases and the current is relatively fast. In these areas, water must have enough dissolved oxygen for eggs and alevins. Pink salmon spawning beds consist primarily of coarse gravel with a few large cobbles and little sand or silt. The female carries 1,500 to 2,000 eggs, digs a nest (or redd) with her tail, and releases the eggs into the nest. Eggs are immediately fertilized by one or more males. After spawning, both males and females die, usually within 2 weeks. Because of the fixed, 2-year life cycle, pink salmon spawning in the same river in odd or even years are reproductively isolated from each other and have developed into genetically different lines. In some river systems, such as the Fraser River in British Columbia, only the odd-year line exists; returns in even years are negligible. In Bristol Bay, Alaska, the major runs occur in even years, whereas the coastal area between these two systems has runs in both odd and even years. The eggs hatch sometime in early to mid-winter. Eggs and alevin require a stable streambed, clean cool water, adequate dissolved oxygen, and relatively little sediment for optimum survival. Overall freshwater survival of pink salmon from egg to advanced alevin to emerged fry, even in highly productive streams, commonly reaches only 10 to 20 percent and at times is as low as about 1 percent. In late winter or spring, the fry emerge from the gravel and out-migrate to the ocean, usually during darkness. Schools of pink salmon fry may move quickly from the natal stream area or remain to feed along shorelines up to several weeks. By late fall, the juvenile pink salmon average 10 to 15 cm in length and grow rapidly (Heard 1991).

Juvenile pink salmon, during their first few weeks at sea, spend much of their time in shallow water only a few centimeters deep. Juvenile pink salmon in the EBS off the northeastern Kamchatka coast are found in one of three hydrological zones during their first 3 to 4 months of marine life: the littoral zone, up to 150 m from shore; open parts of inlets and bays from 150 m to 3.2 km from shore; and open parts of the large Karaginskiy Gulf, 3.2 km to 96.5 km from shore. Ocean migration patterns for pink salmon have been studied. Only stocks that originate in Washington State and British Columbia and those originating in southeastern, central, and southwestern Alaska occur in marine waters where they might interact in some way with the salmon fisheries off the coast of Southeast Alaska. After 18 months in the ocean, the maturing fish return to their river of origin to spawn and die.

Pink salmon adults, eggs, alevins, and fry provide a major nutrient and food source for aquatic invertebrates, other fish, birds (including eagles and gulls), and mammals (including bears, otter, and mink in freshwater systems). In the marine environment, pink salmon fry and juveniles are food for a host of other fishes and coastal seabirds. Subadult and adult pink salmon are known to be eaten by 15 different marine mammals, sharks, other fishes such as Pacific halibut. Because pink salmon are the most abundant salmon in the North Pacific, it is likely that they comprise a significant portion of the salmonids eaten by marine mammals. Millions of pink salmon adults returning to spawn in thousands of streams throughout Alaska provide significant input into the trophic levels of these watersheds.

3.2.1.5.2 Chum Salmon

Chum salmon have the widest distribution, ranging from California to Japan. In the Arctic Ocean, they range from the Mackenzie River in Canada to the Lena River in Siberia. Chum salmon are the most important commercial and subsistence species in Alaska's arctic, northwest, and interior. Chum spawn in streams emptying into the North Pacific Ocean in both Asia and North America. In Asia, chum salmon spawn in streams on the east side of the Korean peninsula in both South and North Korea northward, including Japan, China (tributaries to the Amur River), Russia, and westward into the Arctic Ocean as far west as the Lena River. In North America, chum salmon spawn in streams entering the North Pacific Ocean as far south as northern California and northward in streams along the coasts of Oregon, Washington, British Columbia, and Alaska to the EBS, Arctic Ocean, and the Beaufort Sea as far east as the MacKenzie River in the Northwest Territory. Chum salmon spawn in the Yukon Territory, Canada, and tributaries of the Yukon River. Only small populations spawn north and east of the Noatak River, which enters the ocean at Kotzebue, Alaska, and south of Tillamook Bay, Oregon. In general, their spawning sites are in the lower reaches of coastal streams less than 100 miles from the ocean. In Prince William Sound and in Southeast Alaska, chum salmon will spawn in intertidal portions of streams where groundwater upwells into streams. Chum salmon throughout their range tend to build redds in areas where groundwater upwells in streams, side-channel sloughs, and intertidal portions of streams when the tide is below the spawning area. Many side-channel sloughs have very little current on the surface and can be very silty; however, the upwelling groundwater keeps the silt in suspension in the intragravel water. The upwelling water also keeps the spawning areas from freezing in the winter.

Chum salmon return from the ocean to spawn generally between June and January. Spawning starts earlier in the north and ends later in the southern part of the range. Of course, exceptions to this pattern occur. The latest spawning in Southeast Alaska occurs in the Chilikat River, near Haines Alaska, from September through January. Most chum salmon spawning in Alaska is finished by early November. Most spawning in Washington and Oregon takes place in August through November; however, August spawners have been declining in recent years. Chum salmon return to the Quilcene National Fish Hatchery in December. The Nisqually River, near Olympia, Washington, has spawners during January and February, and sometimes into March.

Summer and fall races of chum salmon occur in Asia and North America. Summer and fall races both enter the Yukon River, with the summer chum entering in May and the fall chum entering in June and July. The fall stocks tend to spawn the farthest up the river from September through November. Summer chum are more abundant than fall chum in the Yukon River; however, the fall chum are larger. In southern Southeast Alaska and northern British Columbia, summer chum enter mostly mainland rivers in mid-June, and spawning may extend into late October and early November. Fall chum in these areas mostly spawn in streams on the islands in September and October. Unlike the Yukon River, summer chum salmon in southern Southeast Alaska and northern British Columbia are larger than the fall stocks for the same age, even though the summer stocks may spawn more than 3 months earlier. Chum salmon vary in size from 2 to more than 13 kg, but usually range from 3 to 8 kg, with females usually smaller than males.

Fertilized eggs incubate in the streambed gravel for about 5 to 8 months. Survival from egg to fry is highly variable, ranging from 1 to 20 percent. Water quality requirements for optimum chum survival are water temperatures above 4º C, salinity less than 2 ppt, and dissolved oxygen levels above 3 to 4 milligrams per liter (mg/L). Spawning beds should be stable and contain low amounts of fine sediment. Like pink salmon, chum salmon outmigrate as fry in the spring after emerging from the gravel. They do not overwinter in streams, but migrate, mostly at night, directly to sea shortly after emergence. Outmigration occurs between February and June, but most fry leave the streams during April and May. Juvenile chum salmon forage in the intertidal grass flats and along the shore for several weeks to months before actively migrating out of bays and estuaries. Estuaries are very important for chum salmon rearing during the spring and summer. Juvenile chum are present in the coastal waters, generally from July through October, and they generally move north and west along the coasts of Oregon, Washington, British Columbia, and Alaska. Most juvenile chum are thought to leave the coastal waters and move south into the North Pacific Ocean between Kodiak Island and False Pass during the fall.

Chum salmon that spawn in both Asia and North America winter in the North Pacific. Asian chum salmon migrate much farther east than North American chum salmon migrate to the west. Asian and North American chum salmon are found intermingled on the high seas. Chum salmon may spend 3 to 5 years feeding and growing to maturity in the ocean before returning to spawn (Salo 1991).

After the 1976-77 regime shift in the North Pacific Ocean, most chum salmon stocks increased in abundance through the mid-1990s. The regime shift apparently created very favorable ocean conditions for all species of salmon from northern British Columbia to northern Alaska. However, as the abundance increased, age at maturity increased, and the size at age decreased drastically. Chum salmon of the same age in the early 1990s weighed up to 46 percent less than they weighed in the early 1970s. During this same time, Asian chum salmon also matured later and their size at age declined. These changes in size at age and age at maturity, as populations increased, suggest that the North Pacific Ocean may have carrying capacity limits for chum salmon under certain conditions.

Chum salmon eggs, alevins, and juveniles in fresh water provide an important food source for many birds (including gulls, crows, magpies, ouzels, and kingfishers), small mammals, other fishes, and many invertebrates. Chum salmon carcasses provide nutrients for the freshwater watersheds and estuaries. The adult chum salmon that return to the Chilkat River system near Haines, Alaska, feed large numbers of bald eagles that congregate on the spawning grounds between September and December. Spawning fish and spent carcasses provide a major food source for brown and black bears, wolverines, wolves, and many other small mammals. Many species of invertebrates also use the carcasses for food. Juvenile chum salmon eat mostly invertebrates, while adults consume amphipods, euphausiids, pteropods, copepods, gelatinous zooplankton, fish, and squid larvae.

Chum salmon are subject to the same habitat concerns as the other species of salmon such as habitat destruction or siltation due to logging and road building, blockages due to dams, and pollution. In addition, chum salmon have two habitat requirements that are essential to their life history: reliance on upwelling groundwater for spawning and incubation and reliance on estuaries/tidal wetlands for juvenile rearing after migrating out of fresh water. The hydrology of upwelling groundwater into stream gravel is highly complex and poorly understood. Activities that change the amount and quality of groundwater that upwells would very likely affect chum salmon survival in a negative manner. Drilling activities, road building, and uplift of land masses due to earthquakes are events known to affect groundwater. Wetlands and estuaries near human development are very vulnerable to pollution and filling activities that would negatively affect essential chum salmon rearing areas.

Chum salmon will spawn in intertidal portions of streams, most notably in Prince William Sound. The intertidal portion of streams is very vulnerable to coastal pollution. In Prince William Sound, chum salmon spawn in the intertidal zone of streams from late June to September. Eggs, alevins, and fry are in the intertidal gravel from late June through May. That leaves a very narrow window in June when the intertidal zone may be free of adults, eggs, alevins, and fry.

3.2.1.5.3 Sockeye Salmon

Sockeye salmon occur widely through the North Pacific Ocean and the Bering and Chukchi seas, from California to northern Hokkaido in the Pacific, and from Bathurst Inlet in Canada to the Anadyr River in Siberia. The primary spawning grounds for sockeye salmon in North America extend from the tributaries of the Columbia River to the Kuskokwim River in western Alaska, and, on the Asian side, mainly on the Kamchatka Peninsula. Spawning populations become more irregular and occasional north of the Bering Strait, on the north coast of the Sea of Okhotsk, and in the Kuril Islands. Centers of the two largest spawning areas in the North Pacific rim occur in the Bristol Bay watershed of southwestern Alaska and the Fraser River drainage of British Columbia. In marine environments along both the Asian and North American coastlines, sockeye salmon occupy ocean waters south of the limits of spawning systems.

Spawning generally occurs in late summer and autumn. Timing of spawning, as in the other species, is temperature-dependent and varies between areas. In Bristol Bay, spawning begins in late July in the smaller streams, in early to mid-August in the tributaries of some lakes, and in late August to mid-September in most lake beach areas. In Lake Kuril and its tributaries, spawning continues from the end of June until early February with the main spawning occurring from September to November. Spawning depth in lakes is not a critical factor and varies widely depending on the habitat in which spawning takes place. Generally, spawning beds are situated in streams with clean gravel or along borders between pools and riffles in shallow water with moderate to fast currents. In large rivers, sockeye spawn in discrete sections of main channels or in tributary channels.

Eggs develop for 5 to 8 months in the gravel. Survival from egg to fry varies from 1 percent to 20 percent. Fry emergence occurs from May to June. Newly emerged sockeye salmon fry actively swim downstream to lakes. Upon entering lakes, fry disperse to feeding areas. Juveniles typically spend one or more growing seasons in the limnetic zone of a nursery lake before smolting.

Sockeye salmon exhibit a greater variety of life history patterns than other members of their genus, and they make more use of lake habitat in juvenile stages. Although sockeye salmon are primarily anadromous, there are distinct populations called kokanee, which mature, spawn, and die in fresh water. Typically, juvenile sockeye use lake rearing areas for 1 to 3 years after emergence; however, some populations use streams for rearing, migrate to sea soon after emergence, and are called age-0 sockeye. Upon entering the ocean, juvenile sockeye salmon remain in a band relatively close to the coast. Off the outer coast of British Columbia and Southeast Alaska, the juveniles are often recorded on the open sea by late June. In July, these fish are found moving northwestward into the GOA. Sampling in the North Pacific has shown that by October, juvenile sockeye are still somewhat distributed primarily nearshore. Evidence indicates the northwestward movement up the eastern Pacific rim is followed by a southwestward movement along the Alaska Peninsula. An offshore movement into the GOA in late autumn or winter is suspected for age-1 sockeye. Sockeye grow quickly and spend 1 to 4 years feeding and growing to maturity in the ocean before returning to spawn. Those fish returning to spawn after only

1 year in the ocean—called jacks—are almost all males. Although sexually mature, they are much smaller in size (often less than 25 cm in length and 250 g in weight) than adult males that have spent several more years feeding in the ocean. Jacks are also common in chinook and coho salmon populations (Burgner 1991). Sockeye are the most important commercial species in Alaska. Adults average from 2 to 3.6 kg.

Sockeye salmon eggs, alevins, and juveniles in freshwater streams and lakes provide an important nutrient and food source for aquatic invertebrates, other fishes, birds, and small mammals. In the marine environment, sockeye salmon juveniles are food sources for many other fishes and coastal seabirds. Adult sockeye are known to be eaten by marine mammals and sharks. Millions of sockeye salmon returning to spawn in thousands of streams provide significant input into the trophic levels of coastal watersheds. Adult sockeye in streams are major food sources for gulls, eagles, bear, otter, mink, and other mammals, as well as for invertebrates. Juvenile sockeye forage on copepods, insects, amphipods, euphausiids, and fish larvae when available.

3.2.1.5.4 Coho Salmon

Coho salmon occur from California through the North Pacific Ocean and southern BS to Siberia, Japan, and Korea. Coho use more diverse habitats than other anadromous salmonids. They spawn in most accessible freshwater streams throughout their range, rear for at least 1 year in fresh or estuarine waters, and spend about 18 months at sea before reaching maturity. In North America, coho range along the Pacific Coast from Monterey Bay, California, to Point Hope, Alaska, through the Aleutians. The species is most abundant in coastal areas from central Oregon north through Southeast Alaska. In the southern part of their range, coho are generally depressed from historical levels, and hatcheries are often used to supplement wild runs. The Central California Coast evolutionarily significant unit (ESU) and the Southern Oregon/Northen California Coast ESU are listed as threatened species under Endangered Species Act (ESA).

In the NMFS' Alaska Region, most coho are wild fish with a distribution north to Point Hope on the eastern Chukchi Sea, west and south to the limits of United States territorial waters, and east to the Canadian border as far north as the Yukon River drainage. Coho catch in the Alaska Region is at historically high levels, and trends in abundance of most stocks are rated as stable.

Adults average between 3.6 and 5.4 kg, but may reach as much as 13.6 kg. Spawning coho are usually the last salmon to arrive, entering fresh water from July to December. Fertilized eggs and larvae require incubation in clean substrate with constant circulation of cool, high-quality water that provides oxygen and removes waste. Sand or silt in the substrate can limit intragravel flow and trap emerging fry. The fry remain in the gravel, utilizing the yolk sac until they emerge in May or June. Coho spend from 1 to 5 years in freshwater streams and lakes before out-migrating to the sea. In Alaska, juvenile coho spend 1 to 2 years in fresh water or estuarine areas before migrating to sea, although they may spend up to 5 years where growth is slow. Coho smolt production is often limited by the productivity of freshwater and estuarine habitats used for juvenile rearing. Survival from eggs to smolt is usually less than 2 percent. Summer habitat carrying capacity usually sets a density-dependent limit on the juvenile population. Coastal streams, lakes, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitats are in smaller streams less than fourth order, which have low gradient alluvial channels with abundant pools often formed by large woody debris or fluvial processes, or beaver dams. Coho juveniles may also use brackish water estuarine areas in summer and migrate upstream to fresh water to overwinter.

During the summer rearing stage, fish density tends to be highest in areas with abundant food (such as aquatic invertebrates, and terrestrial insects that fall into the water) and structural habitat elements (such as large woody debris and associated pools). Coho grow best where water temperature is between 10 and 15º C and dissolved oxygen is near saturation. Juvenile coho can tolerate temperatures between 0 and 26º C if changes are not abrupt. Their growth and stamina decline significantly when dissolved oxygen drops below 4 mg/L, and a sustained concentration below 2 mg/L is lethal. In flowing water, juvenile coho usually establish individual feeding territories, whereas in lakes, large pools, and estuaries, they are less likely to establish territories and may aggregate where food is abundant. In winter, feeding territory is not generally density dependent. It varies directly with fish size, amount of cover, and ponded water and varies inversely with the magnitude of peak stream flow.

The seaward migration of smolts typically occurs in May and June, and it seems to be timed so that the smolts arrive at the estuary when food is plentiful. Smolts are slightly more fragile than juveniles and are susceptible to predation because they are concentrated, and they move along areas of reduced cover where predators congregate. Mortality during migration can exceed 50 percent.

Juvenile coho primarily use estuarine habitat during their first summer and also as they are leaving freshwater during their seaward migration. Intertidal sections of freshwater streams can be important rearing habitat for age-0 coho from May to October. These areas may account for one-quarter of the juvenile production in small streams. Growth in these areas is particularly rapid due to abundant invertebrates that serve as a food source. In fall, juvenile coho from these areas move upstream to fresh water to overwinter.

After leaving fresh water as smolts, coho in the Alaska Region spend up to 4 months in coastal waters before migrating offshore and dispersing throughout the North Pacific Ocean and the EBS. Southeast Alaska juvenile coho are ubiquitous in inside waters from June to August at depths up to 50 m and move offshore in September. Offshore, juvenile salmon are concentrated over the continental shelf within 37 km of shore where the shelf is narrow, but may extend to at least 74 km from shore in some areas.

The amount of time spent at sea varies greatly, but most coho spend 18 months feeding and growing before returning as full-size adults (Sandercook 1991). Coho generally use offshore areas of the North Pacific Ocean and EBS.

Adult coho provide important food for bald eagles, terrestrial mammals (such as brown and black bear and river otter), and marine mammals (such as Steller sea lion, harbor seal, beluga, orca, and salmon sharks). Adult coho play a very important role, as do the other species, in transferring essential nutrients from marine to freshwater environments. Juveniles are eaten by birds (gulls, terns, kingfishers, cormorants, mergansers, and herons), fish (Dolly Varden, steelhead, cutthroat trout, and arctic char), and mammals (mink and water shrew). Juvenile coho are also significant predators of pink salmon fry during their seaward migration. Marine invertebrates are the primary food when coho first enter salt water, and fish prey increase in importance as the coho grow.

3.2.1.5.5 Chinook Salmon

Chinook salmon occur from the Ventura River in California through the North Pacific Ocean, EBS, and Chukchi Sea to the Anadyr River in Siberia and Hokkaido, Japan. The southern edge of marine distribution expands and contracts seasonally and between years depending on ocean temperature patterns. The largest rivers tend to support the largest aggregate runs of chinook salmon and have the largest individual spawning populations. Chinook salmon often make extensive freshwater migrations to their natal steams in some of the larger river systems. Yukon River chinook salmon bound for the headwaters in the Yukon Territory, Canada, will travel more than 2,000 miles in 60 days (Healey 1991). While the marine distribution of chinook salmon can be highly variable even within a population, there are general migration and ocean distribution patterns that are characteristic of populations in specific geographic areas. For example, chinook salmon that spawn in rivers from the Rogue River in Oregon south to California disperse and rear in oceanic waters off the Oregon and California coast, whereas those that spawn north of the Rogue River to southeastern Alaska migrate north and westward along the Pacific Coast. These migration patterns are of particular interest for the management of chinook salmon in the EEZ off Alaska, as they result in the harvest of fish from Oregon, Washington, British Columbia, and Alaska within the management zone. Not all stocks within the area, however, are distributed into the Southeast Alaska fishery. For example, Puget Sound stocks do not normally migrate that far north.

Chinook salmon spawn in a broad range of habitats and have been known to spawn in areas ranging from a few centimeters to several meters deep, in channels ranging from small tributaries 2 to 3 m wide to the mainstems of large rivers such as the Columbia and the Sacramento. Typically, chinook redds are 5 to 15 sq. m with water velocities from 40 to 60 cm/sec, at depths of 20 to 36 cm in the substrate. Eggs will develop in the gravel for 5 to 8 months, and the rate of survival to fry is 30 percent or less.

Some chinook salmon out-migrate to the ocean soon after hatching in late winter or early spring (ocean type), while others remain in fresh water for more than 1 year before out-migrating to the ocean as smolts (stream type). Ocean-type chinook have short, highly variable freshwater residency (from a few days to 1 year) and extensive estuarine residency. They enter fresh water at a relatively mature state and spawn within a few weeks of fresh water entry in the lower portion of the watershed. Stream-type chinook have long freshwater residence as juveniles (1 to 2 years), migrate rapidly to oceanic habitats, enter fresh water as immature fish, and spawn far upriver in late summer or early fall. In Alaska, the stream-type life history predominates, although ocean-type life histories have been documented in a few Alaska watersheds. Chinook salmon become sexually mature in 2 to 7 years; females tend to be older than males at maturity. Fish in any spawning run vary greatly in size, a mature 3-year-old will weigh less than 2 kg, while a mature 7-year-old may exceed 23 kg. Chinook salmon are the largest salmon, often exceeding 14 kg. The largest sport-caught chinook salmon was a 44-kg fish taken from the Kenai River.

Chinook salmon have distinctly different feeding habits and distribution in ocean habitats than do other species of Pacific salmon. Chinook salmon are the most piscivorous of the Pacific salmon and are also distributed deeper in the water column. While other species of salmon generally are surface oriented, primarily utilizing the upper 20 m, chinook salmon tend to occur at greater depths and are often associated with bottom topography. Because of their distribution in the water column, most chinook salmon harvested in commercial troll fisheries are taken at depths of 30 m or greater, and they are the most common species taken as bycatch in mid-water and bottom trawl fisheries.

Declines in the abundance of chinook salmon have been well documented in the southern portion of the range. Concerns over coast-wide declines from southeastern Alaska to the Pacific Northwest was a major factor leading to the Pacific Salmon Treaty between the United States and Canada in 1985. Wild chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California, Oregon, Washington, Idaho, and southern British Columbia. A number of ESUs have been listed by NMFS as at risk of extinction under the ESA. Habitat degradation is the major cause for extinction, and most has been related to dam construction. Urbanization, agricultural land use, and water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon. Most habitat loss has occurred in freshwater ecosystems that support chinook salmon development; estuarine rearing areas have also been affected in some areas by industrial development, urbanization, and dredging.

Dams and impoundments for hydroelectric power and water diversion have caused large-scale extirpation of chinook salmon in the Pacific Northwest by eliminating access to habitat and have altered the spawning, rearing, and migration corridors of chinook salmon in many watersheds. There are presently no dams in place or in planning that would block rivers used by chinook salmon in Alaska. However, because many chinook salmon harvested under the FMP for Alaska originate in the Pacific Northwest, such types of habitat impacts in other regions directly affect the Alaska fishery.

Logging and associated road construction have resulted in degraded habitat by causing increased erosion and sedimentation, changes in temperature regimes, and changes in seasonal flow patterns. Timber harvest has been a major resource use in Southeast Alaska, and is increasing in southcentral Alaska. Timber harvest in the Pacific Northwest and British Columbia also impacts the Alaska fishery because of the presence of stocks from these regions in the Alaska EEZ.

Placer mining has caused serious degradation of chinook habitats in some river systems, especially in the Yukon River drainages. While those impacts are of concern, most of the stocks directly affected do not migrate into the chinook fishery managed under the FMP.

Urbanization and coastal development can have pronounced effects on coastal ecosystems, particularly estuaries, through modification of hydrography, biology, and chemistry in the developed area. Increased nutrient input, filling of productive wetlands, and influx of contaminants commonly occur with coastal development. These impacts can reduce or eliminate rearing potential for juvenile chinook salmon. Increased levels of coastal development can be expected in Alaska, as well as in the Pacific Northwest and British Columbia.

There is a north-south cline to the degree of habitat degradation and the status of chinook populations in the eastern Pacific. Habitat degradation in Alaska is certainly a management concern, but, to date, has not had the degree of impact on chinook populations as it has had in the Pacific Northwest. In Southeast Alaska, logging is considered the largest potential threat to anadromous fish habitat.

The oceanic environment of chinook salmon is considered largely unchanged by anthropogenic activities, although offshore petroleum production and local, transitory pollution events such as oil spills do pose some degree of risk. The development of large-scale hatchery programs has, to some degree, mitigated the decline in abundance of chinook salmon in some areas. However, genetic and ecological interaction of hatchery and wild fish has also been identified as a risk factor for wild populations, and the high harvest rates directed at hatchery fish may cause over-exploitation of co-mingled wild populations.

Chinook salmon eggs, alevins, and juveniles in fresh water provide an important nutrient input and food source for aquatic invertebrates, other fishes, birds, and small mammals. The carcasses of chinook adults can also be an important nutrient input to their natal watersheds, as well as providing food for terrestrial mammals such as bears, otter, mink, and birds (such as gulls, eagles, and ravens). Because of their relatively low abundance in coastal and oceanic waters, chinook salmon in the marine environment are typically only an incidental food item in the diet of other fishes, marine mammals, and coastal seabirds. Food resources for chinook salmon in freshwater environments are larval and adult invertebrates. In estuaries, chinook eat epibenthic organisms, insects, and zooplankton. At sea, chinook eat mostly fish, but also consume squid, pelagic amphipods, copepods, and euphausiids.

For freshwater habitats, habitat-specific information for chinook salmon in particular watersheds is sparse, especially in the northern portion of the range. For estuarine and marine habitats, little data exist beyond presence/absence or density information.

3.2.2 Biology, Status, and Habitat Usage of Species Managed Under Other Authorities

This section provides an overview of the biology and habitat use of species managed under "other authorities," which include the International Pacific Halibut Commission (IPHC), USFWS, and NMFS, the last of which has deferred management of some species to ADF&G. For additional information on habitat use, biology, and population status of these resources, refer to ADF&G (2000b); USFWS' website, http://wwwr7.fws.gov/es/listmarch01.pdf; and IPHC's homepage, http://www.iphc.washington.edu/halcom/default.htm. Section 3.2.1.5 details the biology and distribution of all five species of salmon: pink, chum, sockeye, coho, and chinook. Section 3.4.1.5 contains a brief discussion of salmon fisheries off the coast of Alaska, including the FMP developed by the Council in 1978.

3.2.2.1 Steelhead Trout

The steelhead trout range in Alaska waters extends from Dixon Entrance in Southeast Alaska through the GOA to Cold Bay, Alaska. Steelhead trout are similar to rainbow trout; the greatest difference is their anadromous life history. Rainbow trout spend their entire lives in fresh water. In the spring, steelhead smolt leave their natal streams and enter the ocean when they are about 15 cm in length. Steelhead spend from 1 to 3 years feeding and growing until returning to spawn. Populations return in spring, summer, or fall. Some rivers have more than one run of steelhead each year. Spawning occurs from April through June. Unlike salmon, steelhead commonly spawn more than once, and fish over 70 cm long are commonly repeat spawners. Spent spawners slowly return to the ocean, where they usually spend at least one winter before returning. The eggs quickly hatch and emerge from the streambeds as fry in midsummer, and the steelhead are 5 to 8 cm long by fall. Juvenile steelhead remain in the stream about 3 years before outmigrating to the ocean (Hart 1973).

3.2.2.2 Pacific Halibut

Pacific halibut (*Hippoglossus stenolepsis*) range from the EBS to Oregon, with the center of abundance in the GOA. Spawning takes place in the winter months from December through February. Most spawning takes place off the edge of the continental shelf at depths of 400 to 600 m. Male halibut become sexually mature at 7 or 8 years of age; females mature at 8 to 12 years. In the 1970s, 10-year-old males averaged 9.1 kg, and females averaged 16.8 kg. A few males can grow to 36 kg and live up to 27 years. Females can grow to over 225 kg and live up to 42 years. Females can produce up to 3 million eggs annually. Fertilized eggs float free for about 15 days before hatching; the larvae drift free for up to another 6 months and can be carried great distances to shallower waters by prevailing currents. In the shallower waters, young halibut begin life as bottom dwellers at a length of about 35 mm. Most young halibut spend 5 to 7 years in shallow waters. Younger halibut (up to 10 years of age) are highly migratory and generally migrate in a clockwise fashion throughout the GOA. Older halibut tend to be much less migratory. Halibut prey on a wide variety of fish, crab, and shrimp. Halibut will sometimes leave the ocean bottom to feed on pelagic fish such as herring and Pacific sand lance.

Pacific halibut fisheries are managed by a Treaty between the United States and Canada through recommendations of the IPHC. Pacific halibut is considered to be one large interrelated stock, but is regulated by subareas through catch quotas. The commercial and recreational fishery has a long tradition dating back to the late 1800s.

Fixed Pacific Salmon Commission (PSC) mortality limits have been set for the BSAI groundfish fisheries. Although the annual GOA PSC limits have not changed in recent years, the Pacific halibut mortality limits are not established in regulations but are specified annually by the Council and NMFS. The Council uses the best estimate of halibut bycatch mortality rates each year and the groundfish TAC apportionments to set halibut bycatch mortality allowances for each gear and target fishery group. NMFS monitors halibut bycatch performance throughout the fishing season, including the extrapolation of data to unobserved vessels, and closes fishing by gear group before bycatch mortality limits are reached.

Bycatch of Pacific halibut constrains the groundfish fisheries in both the BSAI and GOA, preventing the TAC of many groundfish target species from being harvested (Witherell and Pautzke 1997). In recent years, halibut mortality limits of 3,675 mt for trawl and 900 mt for nontrawl fisheries have been established in the BSAI. Although halibut mortality limits for the GOA can be changed each year as part of the annual specification process, in recent years they have remained at 2,000 mt for trawl and 300 mt for nontrawl fisheries. For each gear type, these caps have been further apportioned by target species; for each individual target species, they have been further apportioned by season (50 CFR 679.21). This halibut bycatch management program has the effect of directing fisheries to the highest volume or highest value target species with the lowest seasonal halibut bycatch rates throughout the fishing year. Mortality rate assumptions are revisited each year in the annual TAC specification process using information provided by the IPHC. Bycatch rates are based on information collected by independent observers aboard vessels. These data are then extrapolated by NMFS to unobserved vessels' catch for estimates of total bycatch. In recent years, pot gear, jig gear, and hook-and-line gear targeting sablefish under the individual fishing quota (IFQ) program have been exempted from halibut mortality limitations. Other measures taken to reduce the bycatch mortality of halibut have included area closures (both seasonal and year-round), careful release requirements, a vessel incentive program to hold individual vessels accountable for excessive bycatch, public reporting of individual vessel bycatch rates, and gear modifications.

In the GOA, the PSC mortality limit for halibut is 2,300 mt (allocated as 2,000 mt for the trawl fisheries and 290 mt to the hook and line non-demersal shelf rockfish (DSR) fisheries and 10 mt to hook-and-line DSR fisheries). Since 1996, pot gear and jig gear targeting groundfish and hook-and-line gear targeting sablefish have been exempted from PSC caps. These exemptions are due to relatively low bycatch by these gear types and requirements by the sablefish and halibut IFQ program that quota shareholders retain halibut. The 2,000 mt of halibut mortality allocated to trawl gear is further apportioned by season throughout the fishing year and to two target fishery complexes: the shallow water complex (consisting of pollock, pacific cod, shallow-water flatfish, flathead sole, Atka mackerel, and other species) and the deep-water complex (consisting of sablefish, rockfish, deep-water flatfish, rex sole, and arrowtooth flounder). For 2000, neither the 2,000-mt mortality limit for the trawl fisheries nor the 290-mt halibut mortality allocated to the hook-and-line fisheries was exceeded (Table 3.2-1). The 290-mt PSC cap for other hook-and-line fisheries is further apportioned seasonally throughout the fishing year.

The BSAI Pacific halibut PSC mortality limit is 4,575 mt (3,400 mt for trawl and 832 mt for non-trawl gear, and 343 mt for the Community Development Quota [CDQ] program). The trawl mortality component (3,400 mt) is sub-allocated to target groundfish fisheries (Pacific cod, yellowfin sole, rock sole, pollock/Atka mackerel/other species, rockfish, and arrowtooth/sablefish/Greenland halibut). Although the yellowfin sole, rock sole/flathead sole/other flatfish, and pollock/Atka mackerel/other species fisheries exceeded bycatch allocations, the overall halibut PSC limit was not exceeded in 2000 (Table 3.2-2). Except for hook-and-line Pacific cod, none of the fixed gear target fisheries exceeded their bycatch allocations in 2000 (Table 3.2-3).

Figure 3.2-26 shows the halibut bycatch in the bottom trawl fisheries, and Figure 3.2-27 shows the halibut bycatch in the hook-and-line fishery for the BSAI. Both fisheries have halibut bycatch spread throughout the BSAI area.

3.2.2.3 State-Managed Groundfish

3.2.2.3.1 Pacific Cod

The biology, habitat use, and population status of Pacific cod is listed in the overview of federally managed groundfish in this chapter. State-managed cod fisheries were first implemented in 1997 in Prince William Sound, Cook Inlet, Kodiak, Chignik, and South Alaska Peninsula, with up to 25 percent of the federal TAC allocated to the state-managed Pacific cod fishery in each federal management area. The 2001 harvest totaled 9,864 mt.

3.2.2.3.2 Walleye Pollock

The biology, habitat use, and population status of walleye pollock are discussed in the overview of federally managed groundfish in this chapter. In 1995, a state-managed directed pollock fishery was initiated in Prince William Sound, and harvests have averaged 2,259 mt annually. The 2001 harvest totaled 1,422 mt.

3.2.2.3.3 Sablefish

The biology, habitat use, and population status of sablefish is listed in the overview of federally managed groundfish in this chapter. ADF&G actively manages commercial fisheries for sablefish in the Southeast, Prince William Sound, Cook Inlet, and AI management areas. The 2001 harvest totaled 1,562 mt.

3.2.2.3.4 Lingcod

The following is adapted from ADF&G (1998a): Belonging to the family Hexagrammidae, lingcod are greenlings, rather than true cods. They are common throughout Southeast Alaska, Prince William Sound, the outer Kenai Peninsula, and Kodiak. They occur at depths of up to 300 m, but they more typically inhabit nearshore rocky reefs from 10 to 100 m. Most spawning occurs from January through March. They are voracious predators and eat almost anything, including other lingcod. If left unguarded, lingcod egg nests are preyed on by rockfish, starfish, sculpins, kelp greenling, and cod. Salmon, rockfish, and other lingcod eat young lingcod. The maximum age is reported to be 25 years. Lingcod appear to be rather sedentary and are not known to undergo extensive migrations. Their sedentary lifestyle, coupled with their nest-guarding behavior, renders the species particularly sensitive to overfishing. Lingcod, attaining sizes of more than 35 kg are highly prized by commercial and recreational fishermen for their high-quality white flesh. Primary seafood products are fresh and frozen fillets. ADF&G manages all lingcod fisheries in territorial and EEZ waters off Alaska. The 2001 harvest totaled 152 mt.

3.2.2.3.5 Rockfish

The biology, habitat use, and population status of rockfish species is listed in the overview of federally managed groundfish in this chapter. In 1998, black and blue rockfish were removed from the federal FMP and were placed under the management jurisdiction of the State of Alaska. In addition to management of black and blue rockfish throughout all territorial and EEZ waters off Alaska, the state manages rockfish (all species) in Prince William Sound and Cook Inlet. The 2001 rockfish harvests totaled 900 mt.

3.2.2.4 State-Managed Crabs

The biology and habitat usage of most crabs in Alaska fisheries is covered in the federally managed fisheries section in this chapter. The following figures (Figures 3.2-28 through 3.2-34) contain information on the population status of state-managed crab in Alaska.

3.2.2.4.1 BSAI Korean Hair Crab

The Korean hair crab *(Erimacrus isenbeckii)* fishery, which is not included in the BSAI king and Tanner crab FMP, is under exclusive state management. The fishery for hair crab in the EBS was pioneered by the Japanese fleet during the 1960s and was first commercially exploited by the United States fleet in 1978. In the early years of the United States fishery, the hair crab season was opened by emergency order concurrent to the EBS Tanner crab fishery; however, by 1980 a year-long permit fishery had been established. Throughout the 1980s, harvest of hair crabs occurred primarily as bycatch in the EBS Tanner crab fishery. As interest in the fishery and market demand increased, ADF&G began to manage the fishery under conditions of a commissioner's permit. The commissioner's permit fishery was initiated in 1993. Under the permit conditions, all vessels fishing for hair crabs were required to carry an observer during all fishing activities.

Due to increasing effort in the hair crab fishery the Alaska Legislature authorized the Commercial Fisheries Entry Commission to regulate vessel licenses in the EBS hair crab fishery beginning in 1996. Vessel qualification was based on participation in at least one of the qualifying years from 1992 to 1995. Licenses were issued to 23 vessels for those waters beyond 5 nautical miles (nm) off of St. George and St. Paul islands. Also included in this legislation were provisions which allow any vessel 58 feet and under to fish within 5 nm of St. George and St. Paul Islands. In addition, it was the intent of the legislature, expressed in the moratorium, that the Board of Fisheries (BOF) maintain 100 percent observer coverage on all vessels participating in the EBS hair crab fishery. ADF&G exempted vessels under 44 feet in length from mandatory observer coverage because of observer safety considerations.

Participation and harvest in the EBS hair crab fishery have varied greatly over the history of the United States fishery. Effort and harvest reached a peak of 67 vessels and 2.4 million pounds in 1980. Between 1987 and 1990, effort was minimal due to low stock abundance. Since the moratorium, effort has remained at 21 or fewer vessels. In 1997, only 16 vessels made landings. In the 1990s, harvest reached a peak of 2.3 million pounds in 1994. The fishery reached a peak ex-vessel value of $5.7 million in 1995. Since 1995, both effort and Guideline Harvest Level (GHL) have been declining, and the Pribilof fishery has been closed since 1999.

3.2.2.4.2 GOA King and Tanner Crabs

GOA Alaska king and Tanner crab stocks are assessed and managed by the State of Alaska exclusively because no federal FMP for crab has been developed in the GOA. Alaska king and Tanner crab are treated as prohibited species in the groundfish fisheries in the GOA. Alaska king and Tanner crab stocks are severely depressed over much of the GOA. The last king crab fishery in the Kodiak, Chignik, and South Peninsula districts occurred in 1982 and in Cook Inlet in 1983. The red and blue king crab fisheries remained closed in all Districts of the GOA in 2001. The only 2000 Tanner crab fishery in the GOA occurred in the Southeast district. In that fishery, 771 mt of Tanner and 254 mt of golden king crab were harvested. The 2000 survey indicated that the number of legal-size males was sufficient to permit a 2001 Tanner crab fishery in portions of the GOA. GHLs are 227 mt within the Kodiak District and 170 mt within the South Peninsula District. These areas had previously been closed since 1994. There are no crab PSC bycatch limits in the groundfish fisheries in the GOA. To protect crab, large areas of historically important crab habitat have been closed to the use of non-pelagic trawl gear in the GOA. Table 3.2-4 shows the amount of red king crab bycatch in the GOA trawl and fixed gear fisheries. Very little king crab is taken as bycatch in the GOA. A large number of Tanner crabs are taken in the trawl and pot fisheries.

3.2.2.5 Herring

Pacific herring (*Clupea pallasii)* occur from California through the GOA and EBS to Japan. Pacific herring may grow to a length of 45 cm with a weight of over 500 g, but average 23 cm and about 225 g. Pacific herring migrate in schools. In Alaska, Pacific herring begin spawning in mid-March in Southeast Alaska and as late as June in the EBS. Spawning occurs in shallow, vegetated intertidal and subtidal areas. The eggs are adhesive, and survival is greater for those eggs that stick to vegetation than for those that fall to the bottom. Milt released by the males drifts among the eggs, fertilizing them. The eggs hatch in about 2 weeks, depending on water temperature. Herring spawn every year after reaching sexual maturity at 3 or 4 years of age. The average life span of herring is about 8 years in Southeast Alaska and 16 years in the EBS. The young larvae drift and swim with the ocean currents. After developing to their juvenile form, they rear in sheltered bays and inlets and appear to remain segregated from adult populations until they mature. After spawning, most adults leave inshore waters and move offshore to feed, primarily on zooplankton. They are seasonal feeders and accumulate fat reserves for periods of relative inactivity. Herring schools often follow a diel vertical migration pattern, spending daylight hours near the bottom and moving upward during the evening to feed (Hart 1973).

From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes. The major EBS and GOA stocks are currently at moderate levels and in relatively stable condition, with the exception of Prince William Sound and Cook Inlet, which are at depressed levels. Stock assessments indicated that the herring biomass in Prince William Sound and Cook Inlet was below the minimum threshold needed to conduct a harvest, so these fisheries were closed for 1999 and 2000.

Annual statewide harvests of herring were estimated at 36,091 mt for the sac roe harvest through June 21, 2000, and 2,981 mt for the food and bait fishery through November 6, 2000. The Alaska statewide sac roe harvest was about 20 percent less than forecast for 2000, with harvests less than quotas at Kodiak, Togiak, Security Cove, Goodnews Bay, Nunivak Island, and Norton Sound. At Togiak (the largest herring fishery in Alaska) the main spawning run occurred over a very short period in 2000, during which harvest was constrained by the amount of processing capacity on the fishing grounds. Unusual run timing, limited fishing effort, herring availability, and weather were factors limiting harvests in the other areas. Recent statewide harvests have averaged 52,800 mt.

Pacific herring PSC limitations in the groundfish fisheries apply to trawl gear in the EBS. Under Amendment 16 to the BSAI groundfish FMP, the herring PSC limit is set at 1 percent of the EBS spawning biomass, equal to 1,525 mt for 2003. The PSC limit for trawl gear is determined each year during the ABC and TAC setting process and is further apportioned by target fishery (50 CFR § 679.21 (e)(1)(iv)). Should the herring PSC limit for a particular groundfish target fishery be reached during the fishing year, the trawl fishery for that species is closed in the Herring Savings Areas (Figure 3.2-35), (50 CFR § 679.21 (e)(7)(v)). No bycatch allocations were exceeded in 2002.

ADF&G estimated that the 2003 spawning biomass of the EBS herring stock will be approximately 152,500 mt, a decrease from the 1999 estimate of 185,330 mt, primarily due to a more conservative biomass estimate for herring spawning at Togiak (ADF&G website at http://www.cf.adfg.state.ak.us/geninfo/finfish/herring/forecast/01_4cast.htm). All major EBS herring stocks are considered to be healthy and are expected to be above their thresholds in 2003. The 1993 and 1995 year classes appear to be moderately strong in most areas and are expected to sustain healthy spawning populations for several years. The majority of the herring bycatch is taken in the mid-water pollock fishery (Table 3.2-5). Figure 3.2-36 shows the trend of herring catch in the BSAI and the GOA during 1990 to 1998.

3.2.3 Protected Species

The BSAI and GOA support one of the richest assemblages of marine mammals and seabirds in the world. Several of these species are considered "protected species" because of their endangered or threatened status or because of other conservation issues associated with their continued well being. Twenty-six marine mammal species are present from the orders Pinnipedia (seals, sea lion, and walrus), Carnivora (sea otter and polar bear), and Cetacea (whales, dolphins, and porpoises) in areas fished by commercial groundfish fleets (Lowry and Frost 1985, Springer et al. 1999). This region also provides habitat for dozens of species of seabirds (Dragoo et al. 2003), many of which are incidentally taken in commercial fisheries (Melvin and Parrish 2001). Most species are resident throughout the year, while others seasonally migrate into or out of the management areas. Twelve ESUs of endangered or threatened salmon and steelhead also occur in the Alaska EEZ, although all spawn in streams of the U.S. Pacific Northwest, not Alaska. Marine mammals and seabirds occur in diverse habitats, including deep oceanic waters, the continental slope, and the continental shelf (Lowry et al. 1982, Livingston 2002). The following sections contain brief descriptions of the range, habitat, diet, abundance, and population status of these protected species. Incidental take estimates and management measures taken to address interactions with commercial fisheries are included where applicable. Updated information on fishery-related take is summarized in Wilson (2003).

The ESA of 1973, as amended (16 U.S.C. 1531 *et seq*; ESA), provides for the conservation of endangered and threatened species of animals and plants. NMFS administers the program for most marine mammal species, marine and anadromous fish species, and marine plant species, and the USFWS manages ESA-listed bird species, some marine mammal species, and terrestrial and freshwater wildlife and plant species.

The designation of an ESA-listed species is based on the biological health of that species. The status determination is either threatened or endangered. Threatened species are those likely to become endangered in the foreseeable future (16 U.S.C. § 1532[20]). Endangered species are those in danger of becoming extinct throughout all or a significant portion of their range (16 U.S.C. § 1532[20]). Species can be listed as endangered without first being listed as threatened. The Secretary of Commerce, acting through NMFS, is authorized to list marine fish, plants, and mammals (except for walrus and sea otter) and anadromous fish species. The Secretary of the Interior, acting through USFWS, is authorized to list walrus and sea otter, seabirds, terrestrial plants and wildlife, and freshwater fish and plant species.

In addition to listing species under ESA, the critical habitat of a newly listed species must be designated, concurrent with its listing, to the "maximum extent prudent and determinable" (16 U.S.C. § 1533[b][1][A]). ESA defines critical habitat as those specific areas that are essential to the conservation of a listed species and that may be in need of special consideration. Federal agencies are prohibited from undertaking actions that destroy or adversely modify designated critical habitat. Some species, primarily the cetaceans, which were listed in 1969 under the Endangered Species Conservation Act and carried forward as endangered under ESA, have not received critical habitat designations.

Federal agencies have an affirmative mandate to conserve listed species. Federal actions, activities, or authorizations (hereafter referred to as a federal action) must be in compliance with the provisions of ESA. Section 7 of ESA provides a mechanism for consultation by the federal action agency with the appropriate expert agency (NMFS or USFWS). Informal consultations, resulting in letters of concurrence, are conducted for federal actions that may affect, but are not expected to adversely affect, listed species or critical habitat. Formal consultations, resulting in biological opinions, are conducted for federal actions that may have an adverse effect on the listed species. Through the biological opinion, a determination is made as to whether the proposed action is likely to jeopardize the continued existence of a listed species (jeopardy) or destroy or adversely modify critical habitat (adverse modification). If the determination is that the action proposed will cause jeopardy or adverse modification of critical habitat, reasonable and prudent alternatives are included which, if implemented, would modify the action to avoid the likelihood of jeopardy to the species or destruction or adverse modification of designated critical habitat. A biological opinion with the conclusion of no jeopardy or adverse modification may contain recommendations intended to further reduce the negative impacts to the listed species. These conservation recommendations are advisory to the action agency (50 CFR 402.25[j]). If any taking is likely to occur during promulgation of the action, an incidental take statement may be appended to a biological opinion to provide for the amount of take that is expected to occur from normal promulgation of the action.

ESA also provides for the development and implementation of recovery plans for the conservation and survival of listed species. Recovery plans are to include site-specific management actions and measurable criteria that, when met, would result in delisting. Public and private groups and agencies and other institutions may be enlisted to participate in a recovery team. Recovery teams work under public view and must provide for consideration of public comments on a draft recovery plan before plan approval.

Twenty-three species occurring in the GOA and/or BSAI management areas are currently listed as endangered or threatened under ESA (Table 3.2-6). The group includes whales and the Steller sea lion. Other species listed under ESA include Pacific salmon, steelhead, and seabirds (see the following sections). The Steller sea lion was the only species to be determined in jeopardy or at risk of adverse modification of its habitat based upon the FMPs. A complete discussion of the Section 7 consultations to date on the species of relevance can be found in Section 2.9 of the NMFS Groundfish DPSEIS (NMFS 2001a).

3.2.3.1 Steller Sea Lion

The Steller sea lion (*Eumetopias jubatus*) ranges along the North Pacific Ocean rim from northern Japan to California (Loughlin et al. 1984), with centers of abundance and distribution in the GOA and AI, respectively. The northernmost breeding colony in the EBS is on Walrus Island near the Pribilof Islands and in the GOA on Seal Rocks in Prince William Sound (Kenyon and Rice 1961). Evidence of a major decline in Steller sea lion abundance throughout most of its range prompted several environmental organizations to petition NMFS to list all populations of Steller sea lion in Alaska as endangered. On April 5, 1990, NMFS issued an emergency rule (55 FR 12645) to list the Steller sea lion as a threatened species under ESA and established emergency interim measures to begin the population recovery process (55 FR 12645, 55 FR 13488, 55 FR 49204, 55 FR 50005). A recovery plan was completed in 1992, and a Steller sea lion Recovery Team is currently developing an updated recovery plan. In 1997, NMFS reclassified Steller sea lions as two distinct population segments under ESA (62 FR 24345). The population segment west of longitude 144˚ W, or approximately at Cape Suckling, was reclassified as endangered. The eastern stock remains listed as threatened. Both stocks are listed as “depleted” under the Marine Mammal Protection Act (MMPA).

In the EBS and GOA, the Steller sea lion diet consists of a variety of schooling fishes (e.g., pollock, Atka mackerel, Pacific cod, capelin, Pacific sand lance, rockfish, Pacific herring, and salmon), as well as cephalopods such as octopus and squid (Calkins and Goodwin 1988, Lowry et al. 1982, Merrick and Calkins 1995, Perez 1990) and other fishes such as flatfish and scuplins. Recent analyses of fecal samples collected on Steller sea lion haulouts and rookeries suggest that Atka mackerel is particularly important for Steller sea lions in the central and western AI—more than 70 percent of the animals' summer diet in this area is Atka mackerel. Pollock represent more than 60 percent of the diet in the central GOA, 29 percent in the western GOA and eastern AI, and more than 35 percent in parts of the central AI (Merrick and Calkins 1995). Small pollock (less than 20 cm) appear to be more commonly eaten by juvenile sea lions than older animals (Merrick and Calkins 1995).

NMFS observers monitored incidental take in the BSAI and GOA groundfish trawl, longline, and pot fisheries from 1990 to 1995. The minimum estimated mortality rate incidental to commercial fisheries is 30 Steller sea lions per year, based on observer data (23.7) and self-reported fisheries information (5.7), or on stranding data (0.2) where observer data were not available. No Steller sea lion mortality was observed by NMFS in the pot fishery in either the BSAI or GOA (Hill and DeMaster 1999).

Six commercial fisheries currently operate within the range of the endangered western stock of Steller sea lions off Alaska. No sea lion mortality has been observed in several of these fisheries (all pot fisheries and the BSAI longline fisheries). For the most recent 5-year period for the BSAI trawl fisheries, the mean mortality rate was 7.8; in the GOA trawl fisheries, the rate was 0.6; and in the GOA longline fisheries, the rate was 1.2 (Angliss and Lodge 2002). Under the current regulations for the Atka mackerel, Pacific cod, and pollock fisheries in the BSAI and GOA, Steller sea lions are afforded considerably greater protection from both direct take and indirect impacts from fishery removals of prey.

The proposed rule for establishment of critical habitat for the Steller sea lion was published on April 1, 1993 (58 FR 17181), and the final rule was published on August 27, 1993 (58 FR 45269). Habitat includes both marine waters and terrestrial rookeries (breeding sites) and haulouts (resting sites). Pupping and breeding occur during June and July in rookeries on relatively remote islands, rocks, and reefs. Females generally return to the rookeries where they were born to mate and give birth (Alaska Sea Grant 1993, Calkins and Pitcher 1982, Loughlin et al. 1984). Although most often found within the continental shelf region, they may be found in pelagic waters as well (Bonnell et al. 1983, Fiscus et al. 1976, Kajimura and Loughlin 1988, Kenyon and Rice 1961, Merrick and Loughlin 1997). The following areas have been designated as critical habitat in the action area:

(a) Alaska rookeries, haulouts, and associated areas. In Alaska, all major Steller sea lion rookeries identified in 50 CFR, part 226.202, Table 1, and major haulouts identified in 50 CFR, part 226.202, Table 2, as well as associated terrestrial, air, and aquatic zones, have been designated as critical habitat for the Steller sea lion. Critical habitat includes a terrestrial zone that extends 3,000 feet (0.9 km) landward from the baseline or base point of each major rookery and major haulout in Alaska. Critical habitat includes an air zone that extends 3,000 feet (0.9 km) above the terrestrial zone of each major rookery and major haulout in Alaska, measured vertically from sea level. Critical habitat includes an aquatic zone that extends 3,000 feet (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major haulout in Alaska that is east of longitude 144˚ W. Critical habitat includes an aquatic zone that extends 20 nm (37 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of longitude 144˚ W.

(b) Three special aquatic foraging areas in Alaska, including the Shelikof Strait area, the southeastern BS, and the Seguam Pass area.

(1) Critical habitat includes the Shelikof Strait area in the GOA which consists of the area between the Alaska Peninsula and Tugidak, Sitkinak, Aiaktilik, Kodiak, Raspberry, Afognak and Shuyak islands (connected by the shortest lines): bounded on the west by a line connecting Cape Kumlik (56˚38″/157˚26´W) and the southwestern tip of Tugidak Island (56˚24′/154˚41′W) and bounded in the east by a line connecting Cape Douglas (58˚51´N/153˚15´W) and the northernmost tip of Shuyak Island (58˚37´N/152˚22´W).

(2) Critical habitat includes the southeastern BS in the EBS shelf which consists of the area between 170˚00´W and 164˚00´W, south of straight lines connecting 55˚00´N/170 00´W and 55˚00´N/168˚00´W; 55˚30´N/168˚00´W and 55˚30´N/166˚00´W; 56˚00´N/166˚00´W and 56˚00´N/164˚00´W and north of the AI and straight lines between the islands connecting the following coordinates in the order listed:

52˚49.2´N/169˚40.4´W; 52˚49.8´N/169˚06.3´W; 53˚23.8´N/167˚50.1´W; 53˚18.7´N/167˚51.4´W; 53˚59.0´N/166˚17.2´W; 54˚02.9´N/163˚03.0´W; 54˚07.7´N/165˚40.6´W; 54˚08.9´N/165˚38.8´W; 54˚11.9´N/165˚23.3´W; 54˚23.9´N/164˚44.0´W

(3) Critical habitat includes the Seguam Pass area which consists of the area between 52˚00´N and 53˚00´N and between 173˚30´W and 172˚30´W.

Steller sea lion foraging distribution is inferred from at-sea sightings or observations of presumed foraging behavior (Fiscus and Baines 1966, Kajimura and Loughlin 1988, NMFS unpublished data from the Platform-of-Opportunity Program), records of incidental take in fisheries (Perez and Loughlin 1991), and satellite telemetry studies (Merrick et al. 1994, Merrick and Loughlin 1997). Three foraging areas were designated as critical habitat for Steller sea lions based on observations and incidental takes in the vicinity of Seguam Pass, the southeastern BS, and Shelikof Strait (Loughlin and Nelson 1986, Perez and Loughlin 1991).

The value of a given area for foraging sea lions depends not only on the nutritive quality of the prey available, but also on the energetic effort required to obtain that prey. Foraging efficiency, as a function of net energy gain, thus depends in part on how far sea lions must travel, how deep they must dive, and how much time they must spend to catch prey. These parameters have been and continue to be studied with satellite telemetry techniques. The NMFS Alaska Ecosystem program and the ADF&G Steller sea lion research program collaborated to produce a white paper on the use of satellite telemetry to study Steller sea lion movements and foraging behavior (ADF&G and NMFS 2001). The limitations of this data and its use in establishing protective measures for sea lions are described in the Steller Sea Lion Protection Measures FEIS and the associated biological opinion (BiOp) (NMFS 2001b and 2001c). NOAA Fisheries has completed a supplement to the 2001 BiOp which presents recent telemetry data, how that scientific information was interpreted with relation to foraging needs of Steller sea lions, and its relevance to the efficacy of sea lion protection measures (NMFS 2003b). These telemetry studies suggest that foraging distributions vary by individual, size, age, season, site, and reproductive status (Merrick and Loughlin 1997, ADF&G and NMFS 2001, Loughlin et al. 2003).

Compared to other pinnipeds, Steller sea lions tend to make relatively shallow dives, with few dives recorded to depths greater than 250 m. Foraging patterns of adult females differ during summer months when females are with pups versus winter periods when considerable individual variation has been observed. Trip duration (the period between haulouts) for females with young pups in summer is approximately 18 to 20 hours. Dives are typically shallow (mean = 21 m), of short duration (mean = 1.4 min), and frequent (mean = 13/h). Trip length averages 17 km, and sea lions dive approximately 4.7 hours per day. In winter, females with young of the year (5 to 10 months of age) have trips averaging almost 1 day in duration, while females with yearlings (17 to 22 months of age) had trips averaging 2.3 days (Loughlin et al. 2003). During winter, mean trip length is about 130 km, and dives total about 5.3 hours per day (Merrick and Loughlin 1997). In winter, yearling sea lions' foraging trips average 30 km in distance and 15 hours in duration, with less effort devoted to diving than adult females during their trips (mean of 1.9 hours per day). Estimated home ranges are 320 km^2 (with large variation) for adult females in winter, and 9,200 km^2 for yearlings in winter (Merrick and Loughlin 1997).

Recent telemetry studies have examined the movement patterns of immature sea lions (6 to 22 months of age) whose survival rate is considered an important component in the Steller sea lion decline (Loughlin et al 2003). Young-of-the-year sea lions (6 to 12 months of age) had dives that were more brief in duration and more shallow than yearlings (13 to 22 months of age). The length of trips taken by sea lions less than 10 months old was much shorter than trips taken by older juveniles (means = 7.0 km and 24.6 km, respectively). The length of foraging trips, dive characteristics, and depth of dives, began to increase substantially after 9 months of age, corresponding with the presumed age of weaning (Loughlin et al. 2003). This study also compared the diving characteristics of sea lions from Washington with those from Alaska and found that the Washington animals spent more time diving and dove deeper than Alaska sea lions. These differences were attributed to localized differences in where their prey are concentrated (Loughlin et al. 2003). The recent telemetry data suggest that the areas of high use are with 0 to 10 nm of rookeries and haulouts. However, both older juveniles and adult females may utilize the 10 to 20 nm zone of critical habitat to a greater extent in the winter. NOAA Fisheries concluded that the 0 to 10 nm zone was of high concern from potential overlap with fisheries, the 10 to 20 nm zone was low to moderate, and beyond 20 nm was of low concern (NMFS 2003c).

3.2.3.2 ESA-listed Whales

3.2.3.2.1 North Pacific Right Whale

North Pacific right whales (*Eubalaena glacialis*) are known to occur in the North Pacific Ocean and are thought to move from subpolar regions to lower latitudes with the onset of winter (Cumming 1985, Scarff 1986, Rice 1998). A small group of right whales (up to 13 animals) has been seen consistently in the EBS since 1996 (Goddard and Rugh 1998, Tynan 1999, LeDuc et al. 2002), with an additional sighting just south of Kodiak Island in the GOA in July 1998 (Waite 1998). Right whales have been sighted annually during NMFS surveys from 1998 to 2002 (LeDuc et al. 2002). Right whales feed primarily on at least three species of calanoid copepods and, to a lesser extent, on euphausiids (Klumov 1962, Omura et al. 1969). Tynan (1999) sampled zooplankton near right whales seen in the EBS in July 1997 and reported copepod species typical of the middle-shelf assemblage (i.e., *Calanus marshallae*, *Pseudocalanus newmani*, and *Acartia longiremis*), which are smaller species than those that right whales have historically consumed (i.e., *C. plumchrus* and *C. cristatus*) in outer shelf waters.

Right whales are listed as endangered under ESA, and a recovery plan has been written (NMFS 1991). In 1983, a right whale was incidentally killed in a gill net in Russian waters (NMFS 1991). Gill nets were also possibly responsible for the death of another right whale off the Kamchatka Peninsula in October 1989 (Kornev 1994). No other known incidental takes of right whales have occurred in the North Pacific. Any mortality incidental to commercial fisheries would be considered significant (Hill and DeMaster 1999).

On October 13, 2000, NMFS received a petition, dated October 4, 2000, requesting that NMFS revise the present critical habitat designation for the northern right whale under ESA by designating an area within the EBS as critical habitat for northern right whales in the North Pacific. Initially, NMFS published a determination on February 20, 2002, that the recommended action in the petition was not warranted at the time, primarily because the extent of critical habitat could be determined because the essential biological requirements of the population in the North Pacific Ocean were not sufficiently understood. NMFS has reevaluated the petition in light of new and existing information on Pacific right whale habitat following the completion of the 2002 right whale surveys and research and is preparing a document that identifies features of the environment considered to be essential to the conservation of this species. The NMFS Office of Protected Resources is developing an updated recovery plan.

3.2.3.2.2 Blue Whale

Blue whales (*Balaenoptera musculus*) in the North Pacific Ocean presumably migrate between subpolar feeding grounds in spring and summer and low latitudes in winter (Perry et al. 1999a, Rice 1978, Tomlin 1967); however, there is evidence that some whales remain in low latitudes year-round (Reilly and Thayer 1980). Long-term acoustic monitoring has shown that blue whales are heard along the AI westward and in the GOA from late summer through winter (Watkins et al. 2000, Stafford et al. 2001). Recent acoustic monitoring recorded blue whales off the western Aleutians from June to early January and from mid-July to mid-December in the GOA (Stafford in press). Blue whale range does not extend north of the AI, except rarely in the far southeastern corner of the EBS (Rice 1998). Blue whales were harvested in the GOA and along the AI from May to October, with most animals taken from June to August (Berlin and Rovnin 1966, Nishiwaki 1966, Tomlin 1967, Stewart et al. 1987, Brueggeman et al. 1985). However, post-whaling era aerial and visual surveys in former whaling grounds found no blue whales (Rice and Wolman 1982, Stewart et al. 1987). Prey are almost exclusively euphausiids (Kawamura 1980, Nemoto 1970). Blue whales may also eat crab larvae, copepods, and amphipods, but they are not targeting these organisms. In one study of stomach contents from harvested blue whales, copepods made up 0.4 percent, and amphipods made up 1 percent of the stomach contents (Nemoto and Kawamura 1977, Kawamura 1980). Blue whales are listed as endangered under the ESA and depleted under the MMPA.

3.2.3.2.3 Fin Whale

In the North Pacific Ocean, fin whales (*Balaenoptera physalus*) range from the Chukchi Sea to roughly longitude 20˚ N (Leatherwood et al. 1982, Rice 1995). In United States waters, fin whales are distributed seasonally off the coast of North America and in Hawaiian waters (Barlow et al. 1995, McDonald et al. 1995). Acoustic detections of fin whale calls indicate that whales aggregate near the AI in summer (Moore et al. 1998) and near the Hawaiian Islands in winter (McDonald 1999), although some whale calls continue to be detected in northern latitudes throughout the winter with no noticeable migratory movement south (Watkins et al. 2000). Prey includes planktonic crustaceans (euphausiids and copepods), squid, fish (herring, cod, mackerel, pollock, and capelin), and cephalopods (Gambell 1985). The total estimated annual food consumption by the EBS population is 57.5×10^3 mt, of which 9.2×10^3 mt (16 percent) is fish (Perez and McAlister 1993).

Fin whales are listed as endangered under ESA and as depleted under the MMPA. NMFS observers monitored incidental take on the 1990 to 1995 BSAI and GOA groundfish trawl, longline, and pot fisheries. No fin whale mortalities were observed (Hill and DeMaster 1999).

3.2.3.2.4 Sei Whale

Sei whales (*Balaenoptera borealis*) are found in all oceans, but remain in more temperate waters than other baleen whales. They migrate long distances from low-latitude winter areas to higher latitude summer grounds, but infrequently venture into cold, polar waters (Gambell 1976 and 1985, Rice 1998). In the North Pacific Ocean, the summer range extends from southern California to the GOA on the east; across the North Pacific south of the AI, extending into the EBS only in the southeastern corner of the deep southwestern Aleutian Basin; south to Japan on the west; and across the central Pacific north of the subarctic boundary (Gambell 1985, Rice 1998).

In the northern North Pacific, sei whales feed primarily on copepods when available (*Calanus cristatus, C. plumchrus*, and *C. pacificus*), but also on euphausiids such as *Thysanoessa inermis* and *T. longipes*, small schooling fish such as saury, and squid (Kawamura 1973, Nemoto 1959, Nemoto and Kawamura 1977). Sei whales use both engulfing and skimming feeding strategies, depending on the type of prey, unlike other balaenopterids, which feed by engulfing their prey (Nemoto 1959 and 1970, Perry et al. 1999b).

NMFS observers monitored incidental take in the 1990 to 1997 BSAI and GOA groundfish trawl, longline, and pot fisheries, but no mortalities or serious injuries of sei whales were observed (Hill and DeMaster 1999). Sei whales are listed as endangered under ESA. The eastern North Pacific stock is also considered a depleted and strategic stock under the MMPA (Barlow et al. 1997).

3.2.3.2.5 Humpback Whales

Humpback whales (*Megaptera novaeangliae*) are seasonal migrants to the North Pacific Ocean. They feed on zooplankton and small fishes off the coasts of the western continental United States, Canada, and Alaska, as well as eastern Russia. Some have been sighted in the BSAI during the summer. Recent genetic data suggest there are three populations of humpback whales in the Pacific Ocean, and two use Alaska marine waters seasonally. One group winters in the Hawaiian Islands and summers in the GOA and Southeast Alaska areas, and another group likely winters around Japan and migrates to the western GOA and BSAI during the summer. Reliable population trend data for the humpback whale are unavailable (Angliss and Lodge 2002). Humpbacks are listed as endangered under the ESA and depleted under the MMPA.

3.2.3.2.6 Sperm Whales

Sperm whales (*Physeter macrocephalus*) are widely distributed in the North Pacific Ocean and are seasonally present throughout the GOA. This whale is listed as endangered under the ESA and depleted under the MMPA. In the EBS, sperm whales are primarily found in areas from the Pribilof Islands to the west. Female and young sperm whales live primarily in tropical waters, while males are thought to summer in the GOA and BSAI and winter south of 40º. However, recent analyses of older tag data indicate their movement patterns are less clear (Angliss and Lodge 2002). Reliable estimates of sperm whale population trends are unavailable. Sperm whales feed on medium and large squid, as well as on large demersal and mesopelagic sharks, skates, and fishes.

3.2.3.2.7 Bowhead Whale

The western Arctic stock of bowhead whales (*Balaena mysticetus*), the only stock found in United States waters, is widely distributed in the central and western BS in winter (November to April). Bowhead whales are generally associated with the marginal ice front and found near the polynyas of St. Matthew and St. Lawrence Islands and the Gulf of Anadyr (Moore and Reeves 1993). From April through June, these whales migrate north and east, following leads in the sea ice in the eastern Chukchi Sea until they pass Point Barrow, from which they travel east toward the southeastern Beaufort Sea, where most spend June to September (Shelden and Rugh 1995). By late October and November, they arrive in the EBS (Kibal'chich et al. 1986, Bessonov et al. 1990), where they remain until the following spring migration. Studies of stable isotope ratios in bowhead baleen suggest that the Bering and Chukchi seas are the preferred feeding habitats, rather than the Beaufort Sea (Lee and Schell 1999). Historically, there were many records of bowhead whales in the Bering and Chukchi seas in summer (Townsend 1935), possibly consisting of a subpopulation that is now extinct, or nearly so (Bogoslovskaya et al. 1982, Bockstoce 1986).

Prey species identified from bowhead whale stomach contents have included crustacean zooplankton, particularly euphausiids and copepods, ranging in length from 3 to 30 mm, and epibenthic organisms, mostly mysids and gammarid amphipods. No observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska exist (Hill and DeMaster 1999), although there are documented injuries to bowhead whales that may be from encounters with fishing gear (Philo et al. 1992). Bowheads are listed as endangered under the ESA and depleted under the MMPA.

3.2.3.3 Other Marine Mammals

Marine mammal species not listed under ESA are protected under the Marine Mammal Protection Act of 1972 as amended (16 USC 1361-1421h). This act places responsibility for conservation of marine mammals on two agencies: the Department of Commerce for cetaceans and pinnipeds other than walrus, and the Department of the Interior for all other marine mammals, including sea otters, walrus, and polar bear in Alaska. The act provides protection to marine mammals so that they may attain an optimum sustainable population within the carrying capacity of the habitat.

The MMPA prohibits "take" of a marine mammal unless specifically permitted. "Take" is defined as "to harass, hunt, capture or kill, or attempt to harass, hunt, capture or kill" a marine mammal. There are exemptions to some MMPA provisions that allow Native Americans to harvest marine mammals for subsistence uses. There also are allowances for commercial fishing take by permit or authorization by the Secretary.

Marine mammals not listed under ESA that may be present in the BSAI and GOA include the following:

- Cetaceans: gray whale (*Eschrichtius robustus*), minke whale (*Balaenoptera acutorostrata*), killer whale (*Orcinus orca*), beluga whale (*Delphinapterus leucas*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and the beaked whales (Baird's, *Berardius bairdii*; Cuvier's *Zihius cavivostris*; and Stejneger's *Mesoplodon stejnegeri*)
- Pinnipeds: Pacific harbor seal (*Phoca vitulina*), northern fur seal (*Callorhinus ursinus*), Pacific walrus (*Odobenus rosmarus*), spotted seal (*Phoca largha*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*) and ribbon seal (*Phoca fasciata*), and northern elephant seal (*Mirounga angusirostris*)
- Sea otter (*Enhydra lutris*)

Refer to the NMFS draft or revised draft programmatic groundfish SEIS for more details (NMFS 2001a, 2003a).

Gray whales occur across the coastal and shallow water areas of both the eastern and western reaches of the North Pacific Ocean, as well as the Bering, Chukchi, and Beaufort seas. Two stocks are recognized: the eastern North Pacific stock and the western Pacific or Korean stock. The latter stock is considered rare and endangered. The eastern North Pacific stock abundance estimate was 26,635 (CV = 10.06 percent) during the 1997/1998 census (Hobbs and Rugh 1999). The population has been increasing over the past several decades at an estimated annual rate of 3.29 percent (Buckland et al. 1993). Gray whales were originally listed as endangered under ESA, but were delisted in 1994 (Rugh et al. 1999). NMFS observers monitored incidental take in the 1990 to 1998 BSAI and GOA groundfish trawl, longline, and pot fisheries. No gray whale mortalities were observed (Hill and DeMaster 1999).

Taking of the above protected marine mammals in the groundfish and fixed gear fisheries has been monitored through observer programs. The subject groundfish, crab, and scallop fisheries are classified as Category III under the Marine Mammal Protection Act. A Category III fishery means a commercial fishery determined by the Assistant Administrator to have a remote likelihood of, or no known, incidental mortality and serious injury of marine mammals (50 CFR 229.2). Marine mammal interactions are described in the annual status of stocks report for marine mammals (Ferrero et al. 2000, Angliss and Lodge 2002).

3.2.3.4 Endangered and Threatened Pacific Salmon and Steelhead

West Coast salmon species currently listed under ESA originate in freshwater habitat in Washington, Oregon, Idaho, and California. No stocks of Pacific salmon or steelhead originating from freshwater habitat in Alaska are listed under ESA. Some of the listed species migrate as adults into marine waters off Alaska, where the potential exists for them to be caught as bycatch in the BSAI and GOA groundfish fisheries.

ESA-listed West Coast salmon and steelhead species are summarized in Table 3.2-7 and are categorized by ESUs. An ESU is a distinct population segment that is reproductively isolated and contributes to the ecological or genetic diversity of the species (Waples 1991). To date, nine ESUs of chinook salmon, two ESUs of chum salmon, three ESUs of coho salmon, two ESUs of sockeye salmon, nine ESUs of steelhead, and one ESU of sea-run cutthroat trout have been listed as either threatened or endangered under ESA. Of those listed, only six ESUs of chinook salmon, one ESU of sockeye salmon, and five ESUs of steelhead are thought to range into marine waters off Alaska during the ocean migration portion of their life history (Table 3.2-7). Those ESUs that are likely to migrate into marine waters off Alaska are highlighted and are either chinook salmon, sockeye salmon, or steelhead from rivers in Washington and Oregon. NMFS designated critical habitat in 1993 (57 FR 57051) for Snake River sockeye, Snake River spring/summer chinook, and Snake River fall chinook salmon. NMFS designated critical habitat in 2000 (65 FR 7764) for Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River spring chinook salmon and Upper Columbia River, Snake River Basin, Lower Columbia River, Upper Willamette River, and Middle Columbia River steelhead. These designations did not include any marine waters and, therefore, do not include any habitat where Alaska groundfish fisheries are prosecuted.

In the marine waters off Alaska, ESA-listed salmon ESUs are mixed with hundreds to thousands of other salmon stocks originating from the Columbia River in Washington and Oregon and river drainages in British Columbia, Alaska, and Asia. ESA-listed fish are not visually distinguishable from these other, unlisted, stocks. Mortal take of them in the salmon bycatch portion of the fisheries is assumed, based on limited abundance, timing, and migration pattern information gleaned from recovery locations of coded-wire-tagged surrogate stocks (closely related hatchery stocks that are tagged with coded wire tags).

The effects of the BSAI and GOA groundfish fisheries on listed salmon were considered through a series of informal and formal ESA Section 7 consultations with NMFS, Northwest Region, from 1992 to 1999. ESA-listed Pacific salmon were also considered in the FMP level consultation on the groundfish FMPs (NMFS 2000a). The conclusion for Pacific salmon was that "after reviewing the current status, trends, distribution, and abundance of Snake River fall chinook, Snake River spring/summer chinook, Puget Sound chinook, Upper Columbia River spring chinook, Upper Willamette River chinook, Lower Columbia River chinook, Upper Columbia steelhead, Upper Willamette River steelhead, Middle Columbia steelhead, Lower Columbia River steelhead, and Snake River Basin steelhead, in the action area, interactions between these species and the BSAI and GOA groundfish fisheries do not appear to be significant" (NMFS 2000a). Of the chinook and steelhead ESUs considered likely to migrate into marine waters off Alaska, steelhead were considered to be an unlikely component of groundfish bycatch because none were reported as such from 1995 to 1999, and only two coded wire tagged steelhead were recovered in Southeast Alaska seine salmon fisheries sampled from 1982 to 1993.

Chinook salmon and chum salmon are caught incidentally in Alaska groundfish fisheries, primarily in the walleye pollock trawl fishery. On average, from 1990 to 2001, 37,500 chinook salmon and 69,000 other salmon species (more than 95 percent are chum salmon) were caught annually in EBS groundfish trawl fisheries, and 21,000 chinook salmon and 20,500 other salmon were caught annually in GOA trawl fisheries. Factors influencing the level of salmon bycatch are location, gear type, and timing of the fishery (Witherell et al. 2002). Salmon bycatch is primarily composed of juvenile fish that are 1 or 2 years away from returning to the river of origin as adults.

Coded wire tag recoveries of listed chinook salmon surrogate stocks since 1984 are given in Table 3.2-8. Most tag recoveries are from Upper Willamette River chinook ESU surrogate stocks in the GOA, with Lower Columbia River chinook surrogate stock tags also recovered in the GOA. Only two coded wire tags have been recovered in the BSAI from surrogate stocks. Because it is not possible to know if any actual fish from the listed chinook salmon were taken, the 1999 biological opinion assumed that these would be a small fraction of the observed recovery of coded wire tags. An incidental take statement was appended to the biological opinion that allowed for an observed take of 55,000 chinook salmon in the BSAI and 40,000 chinook salmon in the GOA. These are the non-extrapolated bycatch levels expected from current fishing operations. Should incidental take levels exceed these amounts, then consultation should be reinitiated with the anticipated outcome of an incidental take statement commensurate with expected take resulting from normal operations in these fisheries. The NMFS Alaska Region was also given conservation recommendations for chinook salmon to continue to monitor bycatch levels, seek ways to improve region-of-origin and stock composition estimates, and reduce bycatch through regulatory action such as time and area restrictions and incentive programs.

The indirect effects of the BSAI and GOA groundfish fisheries could include impacts to chinook salmon or steelhead prey if they are taken as bycatch in the BSAI and GOA groundfish fisheries or if prey habitat is disrupted by fishing operations. Chinook salmon prey upon fish and invertebrates, including herring (adult and larval), sand lance, juvenile rockfish, pilchards, crab larvae, pelagic amphipods, and euphausiids (Healey 1991). Chinook salmon are considered opportunistic feeders, but fish are more dominant in diets of larger fish while invertebrates are more dominant in the diets of smaller fish (less than 25 inches [63 cm] long). Chinook salmon appear to feed most actively in spring and summer. Steelhead trout are also considered opportunistic feeders, although fish (including juvenile sablefish and rockfish), squid, amphipods, and polychaetes (in some years) predominated in ocean diet studies in the GOA (LeBrasseur 1966, Manzer 1968, Pearcy et al. 1988). Squids predominated in the subarctic current, from 51 to 49° N, fish in areas south of 50° N, and amphipods and polychaetes in areas north of 50° N. High similarities were found in the diets of all Pacific salmon species, and there is little evidence for specialization of diets between them, except for chum salmon.

Many of the prey of salmon are either target species (sablefish, rockfish), prohibited species (herring), or other bycatch species in the BSAI and GOA groundfish fisheries. Squid and other species (sculpin, skate, shark, and octopi) are not targeted by the groundfish fisheries, but bycatch levels are estimated. Forage fish include smelt, euphausiids, deep sea smelts, and lantern fishes. Amendments 36 and 39 of the BSAI and GOA FMPs limit forage fish bycatches through specific catch percentages on all groundfish participants to prevent development of directed forage fish fisheries.

3.2.3.5 ESA-listed Seabirds

Three species of seabirds that range into the BSAI and/or GOA are listed under ESA: the endangered short-tailed albatross (*Phoebastria albatrus*), the threatened spectacled eider (*Somateria fischeri*), and the threatened Steller's eider (*Polysticta stelleri*). The current population status, history of ESA Section 7 consultations, and NMFS actions carried out as a result of those consultations are described in the draft programmatic groundfish SEIS (NMFS 2001a). The life history, population biology, and foraging ecology of these three species are also described in detail in the Steller Sea Lion Protection Measures (NMFS 2001b).

The short-tailed albatross population was drastically reduced early in the century by commercial harvest (Hasegawa and DeGange 1982) and now numbers only about 1,600 breeding birds. Based on egg counts from 1980 to 1998, the population on Torishima Island, Japan (the main breeding site), is increasing at an annual rate of 7 to 8 percent (Cochrane, J., personal communication, USFWS, Grand Marais). Although the short-tailed albatross population is increasing, it is still extremely vulnerable because of its small size and the fact that it breeds on only two islands near Japan, one of which is an active volcano. Short-tailed albatross forage on the outer shelf. They take foods similar to those taken by Laysan and black-footed albatrosses and may forage at night (Sherburne 1993).

USFWS published final rules designating critical habitat for the spectacled eider (66 FR 9146; February 6, 2001) and the Steller's eider (66 FR 8850; February 2, 2001). The marine areas designated as critical habitat are reduced from the areas that were proposed and are further discussed in the draft programmatic groundfish SEIS (NMFS 2001a). No critical habitat was designated within United States territory or waters for the short-tailed albatross.

Critical habitat is defined as the specific areas containing the physical or biological features essential to the conservation of the species and that may require special management considerations or protection. Qualitative criteria used in identifying the eider critical habitat were focused on identifying 1) areas where eiders have been documented as consistently occurring at relatively high densities, 2) areas where eiders are especially vulnerable to disturbance and contamination during breeding, molting, wintering, or flightless periods, and 3) areas essential to the survival and recovery of the species. These final rules do not include requirements or regulations for special management measures or protection areas.

For the spectacled eider, the proposed marine units in the Yukon-Kuskokwim Delta and the North Slope were not designated critical habitat. The proposed marine units in Norton Sound and Ledyard Bay were reduced by 40 and 35 percent, respectively. The proposed wintering marine unit between St. Lawrence Island and St. Matthew Island did not change and was designated as critical habitat. For the Steller's eider, most of the proposed marine units were eliminated (Ninivak Island, Eastern Aleutians, south side of the Alaska Peninsula, Kodiak Archipelago, and Kachemak Bay/Ninilchik). The four units that are designated as critical habitat are subsets of the proposed Kuskokwim Bay (Kuskokwim Shoals and Seal Islands) and the north side of the Alaska Peninsula (Nelson Lagoon [including portions of Port Moller and Herendeen Bay] and Izembek Lagoon). See Figure 3.2-37 for the designated critical habitats for both species and the published final rules for exact coordinates and additional details.

NMFS initiated two Section 7 consultations with USFWS in 2000. The first FMP-level consultation is on the effects of the BSAI and GOA FMPs in their entirety on the listed species (and any designated critical habitat) under the jurisdiction of USFWS (NMFS 2000a). The second consultation is action-specific and is on the effects of the 2001-to-2004 TAC specifications for the BSAI and GOA groundfish fisheries on the listed species (and any critical habitat) under the jurisdiction of USFWS (NMFS 2000b). The most recent biological opinion on the effects of the groundfish fisheries on listed seabird species expired December 31, 2000. NMFS requested and was granted an extension of that biological opinion and its accompanying incidental take statement (USFWS 2001). USFWS intends to issue a biological opinion in mid-2003. This will allow for the consideration of the following new information: recommendations by the Washington Sea Grant Program on suggested regulatory changes to seabird avoidance measures based on a 2-year research program, as well as Council and NMFS action on the proposed alternatives in the Steller Sea Lion Protection Measures SEIS (NMFS 2001b).

Recently, USFWS has determined that trawl gear also may pose a threat to seabirds, primarily albatrosses and fulmars, that may strike the cable (third wire) connecting the trawl sonar device on the headrope to electronic gear on the vessel. No short-tailed albatross have been observed taken on trawl third-wire gear, but mortalities to Laysan albatross have been observed. An incidental take limit (for short-tailed albatross) may be imposed on the trawl groundfish fisheries off Alaska and will be included in USFWS' biological opinion expected in mid-2003. Industry, USFWS, and NMFS are working on a cooperative program to gather additional information on seabird interactions with trawl gear.

3.2.3.6 Other Seabirds

Seabirds spend most of their life at sea, rather than on land. The group includes albatrosses, shearwaters, petrels (*Procellariiformes*), cormorants (*Pelecaniformes*), and two families of *Charadriiformes*, gulls (*Laridae*), and auks (*Alcidae*), which include puffins, murres, auklets, and murrelets. Several species of sea ducks (*Merganini*) also spend much of their lives in marine waters. Other bird groups contain pelagic members, such as swimming shorebirds (*Phalaropodidae*), but they seldom interact with groundfish fisheries and, therefore, will not be further discussed.

Breeding and non-breeding seabird populations ranging into the BSAI and/or GOA include the northern fulmar (*Fulmarus glacialis*), storm petrels, other albatross species, shearwaters (non-breeders in Alaska), cormorants, jaegers, gulls, kittiwakes, terns, murres, guillemots, auklets, murrelets, puffins, and eiders. Most of these species rely primarily on forage fish, although several auklets are more planktivorous and eiders take more crustacea. The life history, population biology, and foraging ecology of these species and species groups are described in detail in the Steller Sea Lion Protection Measures SEIS (NMFS 2001b).

Thirty-eight species of seabirds breed in Alaska. More than 1,600 colonies have been documented, ranging in size from a few pairs to 3.5 million birds. USFWS is the lead federal agency for managing and conserving seabirds and is responsible for monitoring the distribution and abundance of populations. Breeding populations are estimated to contain 36 million individual birds in the EBS and 12 million birds in the GOA; total population size (including subadults and nonbreeders) is estimated to be approximately 30 percent higher. Five additional species that occur in Alaska waters during the summer months contribute another 30 million birds.

Time series data are collected for seabirds by USFWS. Time series data with a duration of 3 years or more exist for northern fulmar, storm petrels, cormorants, gulls, kittiwakes, terns, murres, guillemots, auklets, murrelets, puffins, and eiders. The sizes of breeding populations of seabirds in the GOA, EBS, and AI are not static. The size of breeding populations and discussions of their respective species are presented in the NMFS Groundfish DPSEIS (NMFS 2001a) There have been considerable changes in the numbers of seabirds breeding in Alaska colonies since the original counts made in the mid-1970s. Trends are reasonably well known for species that nest on cliffs or flat ground such as fulmars, cormorants, glaucous-winged gulls, kittiwakes, and murres, as well as for storm petrels and tufted puffins. Trends are known for one or two small areas of the state for pigeon guillemots, two areas for murrelets, and two areas for auklets. Not known are trends for other species (jaegers, terns, most auklets, and horned puffins (Byrd and Dragoo 1997, Byrd et al. 1998 and 1999). Population trends differ among species. Trends in many species vary independently among areas of the state, due to differences in food webs and environmental factors.

Seabirds are characterized by low reproductive rates, low annual mortality, long life span, and delayed sexual maturity—traits that make populations extremely sensitive to changes in adult survival (Ricklefs 1990, 2000). Population trends can result from changes in either productivity or survival, but most trends that have been investigated are attributed to changes in productivity. Such changes may have more to do with the difficulty of obtaining long-term demographic data on seabirds than from a clear link between trends and productivity. Many seabirds have life-history traits that favor adult survival over reproductive effort (Russell et al. 1999, Saether and Bakke 2000). For this reason, Russell et al. (1999) cautions against relying on productivity studies to reach conclusions about population dynamics.

In long-lived animals, observable impact on the breeding population may take years or decades. One study, which modeled impacts of loss of juveniles from longline incidental catch, estimated it would take 5 to 10 years to detect the decline in breeding populations and 30 to 50 years for the population to stabilize after conservation measures were taken (Moloney et al. 1994). A major constraint on seabird breeding is the distance between the breeding grounds on land and the feeding zones at sea (Weimerskirch and Cherel 1998). Breeding success in most species varies among years, but in stable populations, poor success is compensated for by occasional good years (Boersma 1998, Russell et al. 1999). Fluctuations in fish stock recruitment are likely to affect the survival of adult seabirds differently than seabird reproduction. Adult seabird survival is unlikely to be affected by the common interannual variability of prey stock because adults can shift to alternative prey or migrate to seek prey in other regions. In contrast, breeding birds are tied to their colonies, and local fluctuations in fish recruitment can have a dramatic effect on seabird reproduction. If food supplies are reduced below the amount needed to generate and incubate eggs, or if the specific species and size of prey needed to feed chicks are unavailable, local reproduction by seabirds will fail (Hunt et al. 1996). The natural factor most often associated with low breeding success is food scarcity (Kuletz 1983, Murphy et al. 1984, Murphy et al. 1987, Springer 1991, Furness and Monaghan 1987, Croxall and Rothery 1991, Cairns 1992). Seabird populations, therefore, are usually limited by food availability (Furness 1982, Croxall and Rothery 1991).

Foraging ecology differs among seabird species. Diets consist largely of fish or squid less than 15 cm long, large zooplankton, or a combination of both. Most seabirds in a given area depend on one or a few prey species (Springer 1991). Diets and foraging ranges are most restricted during the breeding season, when high-energy food must be delivered efficiently to nestlings, and are somewhat more flexible at other times of the year. Seabird species differ greatly from one another in their requirements for prey and feeding habitats and, consequently, in their response to changes in the environment. Winter foraging ecology is not known for most species (Hunt et al. 1999).

The availability of prey to seabirds depends on a large number of factors and differs among species and seasons. All seabird species depend on one or more oceanographic processes that concentrate their prey at the necessary time and place; these include upwellings, stratification, ice edges, fronts, gyres, and tidal currents (Schneider et al. 1987, Coyle et al. 1992, Elphick and Hunt 1993, Hunt and Harrison 1990, Hunt 1997, review in Hunt et al. 1999, Springer et al. 1999). Prey availability may also depend on the ecology of food species, including productivity, other predators, food-web relationships of the prey, and prey behavior, such as migration of fish and zooplankton. Once prey is captured, its value depends on its energy content.

Access to prey is limited by each bird's foraging behavior and range, as well as by prey size, depth, and behavior. Prey availability and density within each seabird species' foraging range are likely principal factors that determine whether seabird populations are stable, increasing, or declining.

Groundfish fisheries can impact seabird survival directly through incidental take in gear. Seabirds are caught in commercial fishing gear while attempting to seize baits or discards, or while pursuing their natural food near gear. The majority of seabird incidental catch in Alaska groundfish fisheries takes place on longline gear, but trawlers also interact with birds.

Some seabird species scavenge discards from floating and onshore processors. Such behavior may make them vulnerable to being caught in gear. Large-scale exploitation of an artificial food source also can cause a seabird population to increase, which can result in major shifts within the avian food web.

The presence of vessel traffic in Alaska waters imposes the risk of accidents that can affect seabirds, and this risk would be influenced by changes in the number of groundfish vessel days per year. Among the threats to seabirds are oil and fuel spills from collisions, groundings, and routine operations. Another threat from vessels is the introduction of rats to nesting islands from groundings or via ports; rats are voracious predators on young birds and can reduce seabird populations severely.

3.2.4 Other Biological Resources

3.2.4.1 Corals, Sponges, Bryozoans, and Other Sessile Benthic Invertebrates

Offshore areas with substrata of high microhabitat diversity serve as cover for groundfish and other organisms. These include areas with rich epifaunal communities (e.g., coral, sponges, anemones, bryozoans) and areas with large grain sizes (e.g., boulders, cobble). Since many deepwater areas are characterized by stable environments dominated by long-lived species, the potential impacts of fishing on these areas can be substantial and have long-term effects on groundfish and other aquatic species (Auster and Langton 1999).

3.2.4.1.1 Corals

Corals are a diverse group of invertebrates within the phylum Cnidaria. Five major taxonomic groups of corals occur in Alaska waters (Cimberg et al. 1981): Gorgonacea ("hard corals," such as horny corals, sea fans, tree corals, and bamboo corals), Alcyonacea (soft corals), Scleractinia (cup corals or stony corals), Stylasterina (hydrocorals), and Antipatharia (black corals). Approximately 80 species of coral have been reported from Alaska waters (Wing and Barnard, in prep., A Field Guide to Alaskan Corals).

Coral is a living substrate that may serve as fish habitat for some species. The habitat formed by corals supports communities with high biodiversity and may provide shelter for fish (Risk et al. 1998, Fossa et al. 1999). Although scientists have a limited understanding of its importance as fish habitat, deep-water corals clearly provide vertical structure that fish use for protection and cover. Corals have been associated with some rockfish species in Alaska during submersible dives (Krieger and Wing 2000).

Hard corals belong to several diverse orders within the phylum Cnidaria (Barnes 1980). The horny, or fan corals, are members of the order Gorgonacea and comprise all of the corals (with the exception of the soft coral *Gersemia*) that have been identified on the NMFS southeast BS survey (http://www.afsc.noaa.gov/groundfish/HAPC/EBScontents.htm). Horny corals are rare near the edge of the southeast BS shelf and slope (Figure 3.2-38). In the majority of horny corals, growth resembles that of a plant, with a short main trunk fastened to the substrate and lateral branching stems that may be in the same plane. The living tissues are composed of polyps, each with a mouth surrounded by tentacles. Some species are composed of a single polyp while others are colonies of many polyps (Cimberg et al. 1981). Fertilized eggs develop within the female polyps into planula larvae. Planula larvae of most corals are not usually dispersed very far from parent colonies. In colonial species, asexual reproduction also occurs through budding of the primary polyp. Growth of most corals is slow and they may require over 100 years to reach maximum size (Cimberg et al. 1981). Horny corals are suspension feeders, taking their food from the water column. Coral predators include snails, fish, polychaetes, sea stars, and nudibranchs (Cimberg et al. 1981).

Some species of sea fans (such as *Muriceides*) have been reported from the Aleutian Islands and lower EBS along the continental slope and in southeast Alaska. Sea fans were observed, but not identified, in southeast Alaska during submersible dives as part of NOAA's project Sub-Sea. These corals were found at depths of 10 to 2,000 m.

In Alaska, hard corals, particularly gorgonian corals of the genera *Paragorgia* spp and *Primnoa* spp. (red tree coral), may be especially valuable as fish habitat due to the longevity and large size of colonies (Witherell and Coon 2001). *Paragorgia arborea* (Kamchatka coral) is uncommon north of the Alaska Peninsula (Kessler 1985, Heifetz 2002), although recent submersible surveys indicate that it is common on the north sides of the central AI (Stone, R., personal communication, Auke Bay Laboratory). This species ranges from the BSAI to California in depths from 30 to 2,000 m. Kamchatka coral forms large branched colonies (up to 2 m in height). *Primnoa willeyi*, or red tree coral, is rare north of the Alaska Peninsula, but is common in the GOA (Cimberg et al. 1981, Kessler 1985, Heifetz 2002). Red tree coral has been reported from depths of 10 to 800 m and is likely found in greatest abundance between 50 and 250 m. The colonies may survive more than 100 years (Andrews et al. 2002, Risk et al. 2002). Red tree coral colonies may reach 3 m high and 7 m wide.

Fishermen have reported bamboo corals (*Lepsedisis* and *Keratoisis*) from the inside passages of southeast Alaska and in the southeast GOA. These corals have not been reported from the northern portion of the EBS (above 58º N), or from the Chukchi or Beaufort seas. Bamboo corals have the deepest distribution (300 to 3,500 m) of the Alaska corals. Their northern distribution in the EBS and occurrence in deep waters indicate that these corals can live at temperatures less than 3º C. Their distribution also suggests that these corals have a low tolerance for sediments.

Soft corals (Alcyonacea) have the widest geographic range of all Alaska corals and have been reported from the GOA to the Beaufort Sea. These corals are found on cobble and larger substrates, from 10 to 800 m, in areas where temperatures range from -1º C to above 9º C. This species has the widest distributional range, temperature range, and substrate preference of all Alaska corals.

Cup corals (*Balanophyllia* and *Caryophyllia*) differ in geographic range and habitat. *Balanophyllia* has only been reported from southeast Alaska, whereas *Caryophyllia* has been reported from southeast Alaska and Prince William Sound. Neither has been reported in the Bering, Chukchi, or Beaufort seas. Cup corals are predicted to occur in additional regions of the GOA and southeast Alaska, from 0 to 12 m for *Balanophyllia* and from 12 to 400 m for *Caryophyllia*. Since these corals do not appear to tolerate temperatures below 4.5º C, their distribution west of Kodiak Island should be infrequent. Cup corals are not expected to occur in the EBS beyond the AI or in the Chukchi or Beaufort seas.

Hydrocorals (Stylasterina) commonly occur on cobble and larger rocky substrates. Their distribution on the AI suggest that hydrocorals can tolerate temperatures less than 3º C. They can, therefore, be expected to occur in additional regions of the GOA as well as the AI.

Black corals (Antipatharia) are found at depths of 400 m and deeper, typically ranging from 500 to 1,000 m deep. They have been reported throughout the GOA and extending out the AI chain (Wing, B., June 5, 2003, personal communication).

3.2.4.1.2 Sponges

Some information in the paragraph below is adapted from http://www.afsc.noaa.gov/groundfish/HAPC/EBScontents.htm. Sponges (*Phylum Porifera*) are multicellular organisms containing a system of chambers and passageways that allows water to circulate constantly through the body. In many species, body size and shape can vary highly and are strongly influenced by currents and other environmental parameters (Bell and Barnes 2000, Bell et al. 2002). Many sponges have a skeleton consisting of calcium carbonate, silicon dioxide, collagen fibers, or a combination of these substances (Barnes 1980). Sponges reproduce both sexually and asexually. During sexual reproduction, a parenchymella larva develops and swims freely for a short time before settling to the substrate (O'Clair and O'Clair 1998). Sponges are suspension feeders, creating currents that draw in plankton and organic detritus from the water column.

Four species commonly occur in the southeast BS (Figure 3.2-39). *Halichondria panicea*, or barrel sponge, is common north of the Alaska Peninsula. The barrel sponge is a large, thick-walled colony that is highly variable in shape, but may reach a maximum height of 30 cm (Kessler 1985). *Aphrocallistes vastus* is an upright sponge commonly captured during EBS trawl surveys (Malecha et al. unpublished), which grows to 30 cm in height (Kessler 1985). The hermit sponge, *Suberites ficus*, is a small (less than 15 cm) sponge that is common north of the Alaska Peninsula. This sponge species grows over snail shells, which it eventually dissolves, and thus is not attached to any substrate. The shell/sponge is utilized by a hermit crab, hence its common name (Kessler 1985). The tree sponge, *Mycale loveni*, is also common north of the Alaska Peninsula. The tree sponge forms a hard, tree-like skeleton surrounded by soft sponge and attains a maximum height of 25 cm (Kessler 1985). The distribution of sponges off Alaska is described by Malecha et al. (unpublished). Sponges are patchily distributed across the EBS shelf, with low catches relative to other Alaska waters, although high catches are observed near St. George Island (Malecha et al. unpublished). In the western BS, a diverse assemblage of sponges, bryozoans, and hydroids are prime habitat for young-of-the-year red king crab, *Paralithodes camtschaticus* (Tsalkina 1969). Sponges are most commonly associated with rockfish and Atka mackerel in NMFS trawl survey data from Alaska (Malecha et al. unpublished).

3.2.4.1.3 Bryozoans

Information in the paragraphs below is adapted from http://www.afsc.noaa.gov/groundfish/HAPC/EBScontents.htm. Bryozoans are small colonial animals that are common on hard substrates in the southeast BS. They can easily be confused with hydroids and corals. Each individual (called a zooid) in a bryozoan colony is interconnected. Some species produce a non-feeding larva with a brief, free-swimming period, while some larva persist for several months (Barnes 1980). Only the largest, most conspicuous species have been identified from the NMFS southeast BS trawl survey, although none are routinely identified (Figure 3.2-40). About 90 species of bryozoans have been identified in the southeast BS, but intensive collecting might double that number. Roughly two-thirds of the area's known species are low-profile encrusting forms. Rock, live and dead bivalve and gastropod shells, and crab shells are common substrates for attachment. Age and growth rates of bryozoans vary, but many species in the southeast BS probably mature in 1 to 3 years.

In lower Cook Inlet, Alaska, the bryozoans *Flustrella* sp. and *Dendrobeania* spp. were associated with the largest catches of juvenile red king crab (*Paralithodes camtschatica*) (Sundberg and Clausen 1977). Bryozoans were a common component of young-of-the-year red king crab habitat on the west Kamchatka Shelf (Tsalkina 1969), and they were the substrate of choice in laboratory experiments with young-of-the-year and 2- to 3-year-old red king crab (Babcock et al. 1988).

3.2.4.1.4 Other Sessile Epifuana

Other sessile epifuana include hydroids, sea raspberries, sea pens, anemones, sea onions, and sea peaches. Information on these species is adapted from the AFSC website (http://www.afsc.noaa.gov/groundfish/HAPC/ EBScontents.htm).

Hydroids are small, mostly colonial, cnidarians in the class Hydrozoa. Approximately 200 species have been identified in Alaska (O'Clair and O'Clair 1998). Many species encountered on the NMFS trawl survey have yet to be identified. Most species are erect and tree-like, while others are prostrate encrustations on mollusk shells, rock, and other hard surfaces. The erect species generally grow no taller than 15 cm. Some hydroids have alternating benthic and pelagic generations. The pelagic medusae are jellyfish (sizes range from less than 3 mm to more than 250 mm in diameter). Reproduction in the group is varied and complex, with many species having a free-swimming planula larva that spends hours to days in the water column before settling to the bottom (Barnes 1980).

On the west Kamchatka Shelf, a rich assemblage dominated by hydroids, bryozoans, and sponges was the favored habitat of young-of-the-year red king crab (*Paralithodes camtschaticus*), and hydroids were considered to be their main food (Figure 3.2-41). On stations where young crab were caught, hydroids averaged more than 50 percent of the total biomass (Tsalkina 1969). Such strong linkage is not suspected in the southeast BS, although hydroids are part of the sessile invertebrate communities where young-of-the-year red king crab occur (McMurray et al. 1984, Stevens and MacIntosh 1991). In the southeast BS, the hermit crab *Labidochirus splendescens* (splendid hermit) is typically found in a moon snail shell encrusted with the velvet textured hydroid *Hydractinia* sp. (Kessler 1985).

Sea raspberries, *Gersemia* sp., is a colonial soft coral in the class Anthozoa, which also includes the sea anemones, sea pens, and other corals. Soft corals of this genus are found worldwide from the Arctic to the Antarctic (Figure 3.2-42). Two species of sea raspberries are found in the southeast BS: *Gersemia rubiformis* and *G. fruticosa*. These species are distributed in the North Atlantic and in the Pacific from the EBS south to California (Koltun 1955, Gotshall 1994). Within Alaska, *Gersemia* sp. has the widest distributional, temperature, and substrate preference range of all Alaska corals (Cimberg et al. 1981). Kessler (1985) reports it common north of the Alaska Peninsula. When inflated, groups of small polyps form thick, soft, red lobes in colonies that can reach a height of about 25 cm (Koltun 1955). When contracted, the colony has a brain-like appearance and is considerably smaller. Colonies are found attached to stones or shell. *Gersemia* is thought to be a plankton feeder (O'Clair and O'Clair 1998).

Sea whips and sea pens (order Pennatulacea) are colonial octocorals supported by internal skeletal structures and adapted to living as sedentary animals partially buried in fine sediments on the sea floor (Barnes 1980). Spawning may be annual (seasonal) or continual (Eckelbarger et al. 1998). Gametes are released into the water column, where fertilization occurs. Planula larvae settle to the bottom after about 7 days if favorable substratum is available (Chia and Crawford 1973). In Puget Sound, the sea pen *Ptilosarcus gurneyi* is preyed upon by starfish and nudibranchs (Birkeland 1974). Stands of sea whips provide shelter and food for Pacific ocean perch, *Sebastes alutus* (Brodeur 2001). The family Halipteridae has near-cosmopolitan distribution and occurs from 36 to 1,950 m deep (Williams 1999).

One species of sea whip, *Halipteris willemoesi*, has a patchy distribution in the southeast BS, but is commonly found on the outer shelf in the NMFS southeast BS trawl survey (Malecha et al. unpublished) (Figure 3.2-43). A single sea whip is a colony of animals. The base of the colony, or peduncle, anchors the colony to the sea floor by means of peristaltic contractions and hydrostatic pressure. The exposed portion of the colony can reach 2.5 m in height and supports fleshy secondary polyps that cover the hard shaft, or axial rod. Feeding polyps capture small animals. Fish eggs were present in one EBS specimen. Examination of the axial rod reveals more than 100 growth rings that may be annuli. Definitive aging is currently underway.

Sea anemones are members of the Cnidarian order Actiniaria. They attach to hard substrates, including rock and shell. Sea anemones are solitary animals, but they can form dense concentrations. *Metridium* sp. reproduces sexually and eggs are fertilized in the water column, producing planula larvae that eventually settle on suitable substrate (Figure 3.2-44). This species also reproduces asexually by splitting into two pieces in a process called pedal laceration (Wahl 1985). The anemone *Urticina crassicornis* is reported to live at least 60 to 80 years (O'Clair and O'Clair 1998). Some members of the genus *Metridium* reach a height of 51 cm or more (Barr and Barr 1983), but most southeast BS anemones are less than 10 cm in height. *Metridium senile* is capable of restricted locomotion and may also reattach itself after it is detached from the substrate (Wahl 1985). *Metridium* sp. is a suspension feeder, its tentacles selectively trapping zooplankton, eggs, and detritus (O'Clair and O'Clair 1998). Anemones are preyed upon by nudibranchs and sea stars (O'Clair and O'Clair 1998).

Ascidians include members of the genus *Boltenia* (sea onions), *Styela* (sea potato), and *Halocynthia* (sea peach). Two species of *Boltenia* are commonly found in Alaska waters. *Boltenia ovifera*, a stalked, solitary ascidian, is widely distributed in the North Atlantic and North Pacific, including Alaska (Malecha et al. unpublished) (Figure 3.2-45). *Boltenia villosa* is also common in the region. *Boltenia ovifera* is locally abundant north of the Alaska Peninsula (Kessler 1985). This species is found in the Okhotsk and Bering seas, mainly at depths of 25 to 100 m, usually together with sponges and hydroids (Ushakov 1955). Sexual reproduction results in the formation of a tadpole larva that is free-swimming for only hours before it settles on a hard substrate and begins its metamorphosis to the adult form. In the Bay of Fundy, the tadpole larvae appeared in the plankton in January and February, far preceding the appearance of any other plankton (Lacalli 1981). The adult sea onion has a white or pinkish bulb-like body that floats in the water column and is tethered to the bottom by a stalk that terminates in a root-like holdfast or hapteron. The stalk is usually two to three times the length of the bulbous body, with the entire animal reaching 30 cm or more in length (Kessler 1985). Compound ascidians like *Molgula* sp, bryozoans, and hydroids are frequently attached to the stems and holdfasts of sea onions. Sea onions and associated attached invertebrates are known to provide habitat to small juvenile red king crab (*Paralithodes camtschaticus*) (McMurray et al. 1984, Stevens and Kittaka 1998).

Sea potatoes, *Styela rustica*, grow in clumps and are permanently attached to snail or clam shells, or to other invertebrates such as mussels. They are abundant north of the Alaska Peninsula and are relatively common in the 40- to 100-m depth range. The sea potato is so named due to its dark brown coloration and potato-shaped body, which can reach a maximum size of 10 cm (Kessler 1985).

The sea peach, *Halocynthia aurantium*, occurs from the Arctic, throughout the EBS, and south to Puget Sound (Ushakov 1955, Gotshall 1994). The sea peach is common north of the Alaska Peninsula (Kessler 1985). It is most common in depths of 40 to 100 m in the southeast Bering, northeast Bering, and southeast Chukchi seas (Jewett and Feder 1981) (Figure 3.2-46). The sea peach has a barrel-shaped body that is directly attached to the substrate. The red-to-orange outer covering is smooth or wrinkled and has two large siphons on top. It grows up to 18 cm (Kessler 1985). This large, solitary ascidian is often found in groups (Ushakov 1955). In the western BS, *Halocynthia* is preyed upon by the crabs

Chionoecetes opilio and *C. bairdi* (Ivanov 1993). It is also preyed upon by the sea star *Evasterias troschelii* (Barr and Barr 1983).

3.2.4.2 Forage Fish

Forage fish, as a group, occupy a central position in the North Pacific Ocean food web, being consumed by a wide variety of fish, marine mammals, and seabirds. Many species undergo large fluctuations in abundance. Most of these are R-selected species (e.g., pollock, herring, Atka mackerel, capelin, and sand lance), which generally have higher reproductive rates, are shorter-lived, attain sexual maturity at younger ages, and have faster individual growth rates than K-selected species (e.g., rockfish and many flatfish, which are species that are generally long-lived, reach sexual maturity at an older age, and grow slowly). Predators that use R-selected fish species as prey (marine mammals, birds, and other fish) have evolved in an ecosystem in which fluctuations and changes in relative abundance of these species have occurred. Consequently, most of them, to some degree, are generalists that are not dependent on the availability of a single species to sustain them, but instead rely on a suite of species, any one (or more) of which is likely to be abundant each year. However, differences in energy content exist among forage species, with herring, sand lance, and capelin containing higher energy content per unit mass than other forage species such as juvenile pollock (Payne et al. 1997). It is possible that changes in availability of higher energy content forage may influence growth and survival of the upper-trophic-level species reliant on forage species as their main prey.

Some evidence exists that osmerid abundance, particularly capelin and eulachon, has significantly declined since the mid-1970s. Evidence for this comes from marine mammal food habits data from the GOA (Calkins and Goodwin 1988), as well as from data collected in GOA biological surveys not designed to sample capelin (Anderson et al. 1997) and EBS commercial fisheries bycatch (Fritz et al. 1993). It is not known, however, whether smelt abundance has declined or whether the populations have redistributed vertically, presumably due to warming surface waters in the region beginning in the late 1970s. This conclusion could also be drawn from the data presented by Yang (1993), who documented considerable consumption of capelin by arrowtooth flounder, a demersal lower-water-column feeder, in the GOA.

Distribution, species associations, and biomass trends of various forage fishes in the EBS were recently summarized by Brodeur et al. (1999). In addition to observations on the eastern shelf, this summary also included data from two Russian cruises that covered both eastern and western BS shelf regions in 1987. Spatial distributions of some forage species in the EBS (age 1 pollock, age-1 cod, Pacific herring, capelin, and eulachon) showed some spatial separation of the groups and some changes in distribution in a cold versus a warm year. Capelin were associated with colder temperatures in the northern part of the study area, while age-0 pollock were associated with warmer temperatures than the overall measured temperature. Eulachon were found only in the warmer temperatures at the southern part of the sampling area. Although this study did not find any long-term trends in forage fish abundance in the EBS, the study period began in 1982, which is generally considered to be a warmer period in the EBS. Analysis of 36 years of Russian pelagic trawl data indicates different periods of fish abundance, depending on environmental conditions. In the western BS and the Okhotsk Sea, herring and capelin appear to alternate in abundance with pollock. Such a pattern has not been definitively identified for the EBS.

A review of the biology of smelts (capelin, rainbow smelt, and eulachon, family Osmeridae), which are slender schooling fishes that can be either marine, such as capelin (*Mallotus villasus*), or anadromous, such as eulachon (*Thaleichthys pacificus*), is provided in the following sections.

3.2.4.2.1 Capelin

Capelin are distributed along the entire coastline of Alaska and south along British Columbia to the Strait of Juan de Fuca. In the North Pacific Ocean, capelin can grow to a maximum of 25 cm at age 4. Most capelin spawn at age 2 or 3, when they are only 11 to 17 cm (Pahlke 1985). Spawning occurs in spring in intertidal zones of coarse sand and fine gravel, especially in Norton Sound, northern Bristol Bay, and around Kodiak Island. Very few capelin survive spawning. The age of maturity of capelin in the Barents Sea has been shown to be a function of growth rate, with fast-growing cohorts reaching maturity at an earlier age than slow-growing cohorts. Thus, it is possible to have slow- and fast-growing cohorts mature in the same year, resulting in large spawning biomasses 1 year preceded and potentially followed by small spawning biomasses.

In the EBS, adult capelin are only found nearshore during the months surrounding the spawning run. During other times of the year, capelin are found far offshore in the vicinity of the Pribilof Islands and the continental shelf break. The seasonal migration may be associated with the advancing and retreating polar ice front, as it is in the Barents Sea. In the EBS, winter ice completely withdraws during the summer months. If migration follows the ice edge, the bulk of the capelin biomass in the EBS could be located in the northern BS, beyond the area worked by the groundfish fisheries and surveys. Very few capelin are found in surveys, yet they are a major component of the diets of marine mammals feeding along the winter ice edge (Wespestad 1987) and of marine birds, especially in the spring. In the GOA, which remains ice-free year-round, capelin overwinter in the bays of Kodiak Island and in Kachemak Bay.

Capelin have shown abrupt declines in occurrence in small-mesh trawl survey samples in the GOA (Piatt and Anderson 1996, Anderson and Piatt 1999). In both NMFS and ADF&G survey data, capelin first declined along the east side of Kodiak Island and bays along the Alaska Peninsula. Subsequent declines took place in the bays along the west side of Shelikof Strait. These declines happened quickly, and low abundance has persisted for more than a decade. The decline was coincident with increases in water temperature of the order of 2º C, which began in the late 1970s. Capelin have fairly narrow temperature preferences and probably were very susceptible to the increase in water column temperatures (Piatt and Anderson 1996, Anderson et al. 1997). Mapping of relative densities of capelin showed defined areas of relative high abundance. The Shelikof Strait region showed relatively high catches in Kujulik, Alitak, and Olga bays. Most catches of capelin were closely associated with bays, except for high catches offshore of Cape Ikolik at the southwest end of Kodiak Island. Isolated offshore areas east of Kodiak Island showed some high catches, with most associated with Ugak and Kazakof bays. Only isolated catches of less than 50 kg were evident in the database from Prince William Sound, the Kenai Peninsula, and lower Cook Inlet.

The diet of capelin in the North Pacific Ocean, as summarized by Hart (1973) and Trumble (1973), is primarily planktivorous. Small crustaceans such as euphausiids and copepods are common to the diet of capelin, although marine worms and small fish are also part of their diet. In the EBS, adult capelin consume copepods, mysids, euphausiids, and chaetognaths. Juveniles primarily consume copepods (Naumenko 1984). The largest capelin (over 13 cm) consume euphausiids almost exclusively. Capelin feed throughout the year in the EBS. However, the diet exhibits seasonal variation that is due in part to spawning migration and behavior.

The primarily planktivorous diets of eulachon, sand lance, and capelin reduce the potential for dietary competition with the piscivorous and benthic diets of most groundfish. However, the potential for dietary competition is greater between pollock and forage fish due to the importance of planktonic prey, such as euphausiids and copepods, in their diets.

3.2.4.2.2 Eulachon

The eulachon, *Thaleichthys pacificus*, an anadromous, short-lived member of the Osmerididae (smelts), spawns in the lower reaches of coastal rivers and streams from northern California to Bristol Bay. This fish plays a significant cultural and ecological role in the coastal areas of Alaska. Eulachon have been, and continue to be, an important food source for humans and an important prey species for marine mammals such as the Steller sea lion and for fish. The number of streams supporting eulachon runs on the west coast of North America is relatively small, and most of the streams are mainland glacier-fed systems. Southeast Alaska has more than 25 streams with runs of eulachon. Their abundance throughout their range appears to have been declining since the early 1980s, though very little is known about them. Eulachon spawn in the spring in rivers of the Alaska Peninsula and possibly in other rivers draining into the southeastern BS. Eulachon can live to age 5 and grow to 25 cm, but most die following their first spawning at age 3. Eulachon are consistently found by groundfish fisheries and surveys between Unimak Island and the Pribilof Islands in the EBS, and in Shelikof Strait in the GOA. Evidence from fishery observer and survey data suggests that eulachon abundance declined in the 1980s (Fritz et al. 1993). These data should be interpreted with caution because surveys were not designed to sample small pelagic fishes such as eulachon, and fishery data were collected primarily to estimate total catch of target groundfish. Causes of the decline, if real, are unknown, but may be related to variability in year-class strength, as noted for capelin. Small-mesh shrimp trawl surveys in the GOA coastal areas suggest that eulachon has remained at a low level of relative abundance since 1987.

The diet of eulachon in the North Pacific Ocean generally consists of planktonic prey (Hart 1973, Macy et al. 1978). As larvae, they primarily consume copepod larvae; post-larvae consume a wider variety of prey, including phytoplankton, copepod eggs, copepods, mysids, ostracods, barnacle larvae, cladocerans worm larvae, and larval eulachon. Juvenile and adult eulachon feed almost exclusively on euphausiids, with copepods and cumaceans occasionally in the diet.

3.2.4.2.3 Pacific Sand Lance

Pacific sand lance (*Ammodytes hexapterus*, family Ammodytidae) are usually found on the sea bottom, at depths between 0 and 100 m except when feeding (pelagically) on crustaceans and zooplankton. Spawning is believed to occur in winter. Sand lance mature at 2 to 3 years and lengths of 10 to 15 cm. Little is known of their distribution and abundance; they are rarely caught by trawls. In the EBS, sand lance are common prey of salmon, northern fur seals, and many marine bird species. Thus, they may be abundant in Bristol Bay and along the AI and Alaska Peninsula. In the GOA, sand lance are prey of harbor seals, northern fur seals, and marine birds, especially in the Kodiak Island area and along the southern Alaska Peninsula. Given the sand lance's short life span and the large number of species that prey on it, mortality, fecundity, and growth rates are probably high.

Sand lance in the Kodiak Island region undergo an extensive migration that is counter to the normal pattern found with many inshore species. Spawning takes place in the late fall and winter and is usually completed in January. Hatching of larvae continues over an extended time, until March and perhaps April (Blackburn et al. 1983, Blackburn and Anderson 1997), and some larval fish may spend up to several months in beach sediments. Newly hatched larval sand lance and adults start migrating offshore in the early spring and spend some time in offshore bank areas, where they can often be abundant (Clemens and Willoughby 1961). Offshore ichthyoplankton surveys in the GOA indicated high larval abundance, first appearing in early March and remaining high until early July, but then disappearing. In the late summer, massive schools of fish start migrating inshore to suitable beach habitat for spawning and overwintering. These inshore migrating schools provide important forage for species such as offshore migrating seabirds during late summer and early fall. Hence, sand lance are among the few fish that migrate inshore during the late summer months to overwinter near-shore, while most other fish migrate offshore prior to winter months.

Hart (1973) and Trumble (1973) summarized the diet of sand lance in the North Pacific Ocean as primarily planktivorous, their primary prey changing with ontogeny. Larval sand lance consume diatoms (microscopic one-celled or colonial algae) and dinoflagellates (photosynthetic marine organisms); post-larvae prey upon copepods and copepod nauplii. More recent information on the food habits of age-0 and age-1 sand lance shows a dominance of calanoid copepods in the diet, with barnacle nauplii, larvaceans, and shrimp larvae as other important prey (Blackburn and Anderson 1997). Adult sand lance prey upon chaetognaths, fish larvae, amphipods, annelids, and common copepods. Sand lance exhibit seasonal and diurnal variation in feeding activity and are opportunistic feeders upon abundant plankton blooms.

3.2.4.2.4 Significance of Forage Fish in the Diet of Eastern Bering Sea Groundfish

In the EBS, forage fish, as defined here, are found in the diets of pollock, Pacific cod, arrowtooth flounder, Pacific halibut, Greenland halibut, yellowfin sole, rock sole, Alaska plaice, flathead sole, and skates. However, forage fish do not represent a large portion of the diet, by weight, of these predators, with the exception of shelf rock sole (14.3 percent) and slope pollock (12.6 percent). Tables 3.2-9 and 3.2-10 present the ten most important prey, by weight, in the diets of each predator for the EBS shelf and slope regions, respectively. Forage fish that are in the diet, but not one of the ten most important prey by weight, are also listed. The miscellaneous fish category represents all fish prey not included as one of the ten most important prey categories, primarily unidentified fish. All groundfish diet data are from AFSC's Resource Ecology Fishery Management Division, groundfish food habits database.

Despite the generally piscivorous diet of cod, arrowtooth flounder, Pacific halibut, Greenland halibut, and skates, forage fish are not principal components, by weight, in the diets of EBS groundfish (Table 3.2-9). Sand lance are the most prevalent forage fish in the diet of cod (0.8 percent) while capelin, osmerids, bathylagids, myctophids, and eulachon each represent 0.1 percent or less of the diet by weight. In the diet of arrowtooth flounder, capelin and eulachon each represent 0.2 percent of the diet by weight, while osmerids, myctophids, and sand lance each constitute 0.1 percent or less. The diet of Pacific halibut contains 2.2 percent sand lance and 1.8 percent capelin; osmerids and eulachon each represent 0.1 percent or less. Myctophids represent 0.2 percent of the diet of Greenland halibut; bathylagids, osmerids, and sand lance represent 0.1 percent or less. Sand lance are the most important forage fish in the diet of skates (0.7 percent); capelin, sandfish, and myctophids each represent 0.1 percent or less. Sand lance is the most prevalent forage fish species in the diet of pollock (0.5 percent); osmerids, bathylagids, myctophids, and eulachon each represent less than 0.1 percent of the diet by weight. The total contribution (0.6 percent) of forage fishes to the diet of yellowfin sole is primarily due to sand lance; bathylagids and capelin each represent less than 0.1 percent by weight. Sand lance are the second-most important prey in the diet of rock sole, 14.3 percent by weight; osmerids are the only other forage fish present in the diet (less than 0.1 percent). Sand lance are the only forage fish found in the diet of Alaska plaice, representing 0.5 percent of the diet. Flathead sole consume capelin (1.3 percent), sand lance (0.5 percent), osmerids (0.1 percent), and myctophids (less than 0.1 percent).

Lang and Livingston (1996) studied the diets of groundfish in the EBS slope region. In this region, forage fish are relatively unimportant in the diets of Greenland halibut, flathead sole, arrowtooth flounder, and cod (Table 3.2-10). However, 12.6 percent of the diet of pollock on the slope consists of forage fishes. Greenland halibut consume bathylagids (0.4 percent) and myctophids (0.4 percent) as the only forage fish in their diet. Flathead sole also consumed bathylagids (0.3 percent) and myctophids (0.1 percent). Myctophids (0.2 percent) are the only forage fish found in the diet of arrowtooth flounder.

Pollock consume bathylagids (7.0 percent), myctophids (5.5 percent), osmerids (0.1 percent), and sand lance (less than 0.1 percent). Forage fish are negligible in the diet of cod; bathylagids represent less than 0.1 percent of the diet by weight.

3.2.4.2.5 Significance of Forage Fish in the Diet of Gulf of Alaska Groundfish

Yang and Nelson (2000) studied the diets of groundfish in the GOA shelf during summer. They found that the main fish prey of groundfish in the GOA included pollock, Pacific herring, capelin, Pacific sand lance, eulachon, Atka mackerel, bathylagids, and myctophids (Table 3.2-11). Although pollock was the most important fish prey of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and pollock in the GOA, other forage fish species comprised 1 to 23 percent of the diet of groundfish. Capelin was important food of arrowtooth flounder and pollock, comprising 23 and 7 percent of the diet of arrowtooth flounder and pollock in 1990, respectively. The consumption of the capelin by pollock gradually decreased to 3 percent in 1993 and to 0 percent in 1996. Compared to 1990, arrowtooth flounder also consumed less capelin in 1993 (4 percent) and in 1996 (10 percent). The capelin consumed by these groundfish were mainly located northeast and southwest of Kodiak Island. Eulachon comprised 6 percent of the food of sablefish. Myctophids were important forage fish for shortraker rockfish, comprising 18 percent of the diet of shortraker rockfish. Pacific sand lance were found in the stomachs of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and pollock, but their contribution to these diets was small (1 percent or less). Bathylagids were only found in the diet of pollock, and they contributed less than 1 percent. Pacific sandfish was not found in the diet of the groundfish in the GOA.

In the Atlantic, strong interactions between cod and capelin have been recorded (Akenhead et al. 1982). Even though Pacific cod did not feed so heavily on capelin in the GOA, capelin was an important fish prey of several groundfish species. The distribution and the abundance of forage fish in the GOA are not well known. However, a series of years with poor forage fish recruitment, which decreases the availability of small prey fish, could potentially have an impact on piscivorous groundfishes.

3.2.4.2.6 The Significance of Forage Fish in the Diet of Aleutian Islands Groundfish

Yang (1996) studied the diets of groundfish in the AI during summer. He found that main fish prey of groundfish in the AI included Atka mackerel, pollock, Pacific herring, capelin, myctophids, bathylagids, Pacific sand lance, and eulachon (Table 3.2-12). Although Atka mackerel and pollock were important fish prey of arrowtooth flounder, Pacific halibut, and Pacific cod, other forage fish species comprised from 1 to 37 percent of groundfish diets. Most of the Atka mackerel consumed by the groundfish were located near Attu, Agattu, Amchitka, Tanaga, Atka, and Unalaska Islands. Myctophids were an important forage fish. Large amounts of myctophids were found in the diets of Greenland halibut, pollock, Pacific ocean perch, and shortraker rockfish. They were also found in arrowtooth flounder, Pacific cod, rougheye rockfish, Atka mackerel, and northern rockfish. Most myctophids consumed by the groundfish were located near Kiska, Adak, Seguam, and Yunaska Islands. Nine out of eleven groundfish species shown in Table 3.2-12 consumed myctophids as food. If the abundance of the myctophids declines dramatically, it could impact the growth of AI groundfish, which depend on myctophids for a main food resource. Bathylagids were found in the diets of Greenland halibut and pollock. Capelin were found in the diet of Pacific halibut and pollock collected in the Akutan Island area, but they contributed only 5 percent and less than 1 percent of the diets of Pacific halibut and pollock, respectively. Pacific sand lance were food for arrowtooth flounder, Pacific halibut, Pacific cod, and pollock, but they contributed less than 1 percent of these diets. Only a small amount (less than 1 percent) of eulachon was found in the diet of pollock. Pacific sandfish was not found in the diets of the groundfish in the AI area.

3.2.4.3 Squid and "Other Species"

Other species include those species that are not commercially targeted, but that are caught as bycatch within commercial fisheries governed by FMPs. The true "other species" group is made up of squid (considered separately) and sculpin, skate, shark, and octopi (which comprise the true other species category). Because data are insufficient to manage each of the other species groups separately, they are considered collectively. Neither squid nor any of the species, with the exception of skates, in the other species category are currently targeted by the BSAI and GOA groundfish fisheries. As such, they are only caught as bycatch by fisheries targeting groundfish. Beginning in 1999, smelt was removed from the other species category and placed—along with a wide variety of other fish and crustaceans including krill, deep-sea smelts, and lantern fishes—in the forage fish category. This action was accomplished through Amendments 36 and 39 (Appendix 1) to the BSAI and GOA groundfish FMPs. These amendments place specific catch percentage limits for forage fish on all groundfish fishery participants in order to prevent the development of directed forage fish fisheries.

Skate species include Alaska skate (*Bathyraja pamifera*), big skate (*Raja binoculata*), longnose skate *R. rhina*), starry skate *R. stelluata*), and Aleutian skate (*B. aleutica*). The predominant shark species is spiny dogfish (*Squalus acanthias*), with sleeper sharks (*Somniousus pacificus*) and salmon sharks (*Lamna ditropis*) occasionally taken. Octopus species include *Enteroctopus dofleini* and *Opisthoteuthis californiana*.

3.2.4.3.1 Squid

Squid are found throughout the Pacific Ocean. They are not currently the target of groundfish fisheries in the GOA or BSAI, although they are taken as bycatch in pollock and rockfish trawl fisheries. The red (magistrate) armhook squid is probably the best known species found in Alaska waters. It is abundant over continental slopes throughout the North Pacific Ocean from Oregon to southern Japan (Nesis 1987). It is the basis of fisheries in both Russian and Japanese waters. Little is known about the reproductive biology of squid. Fertilization is internal, and juveniles have no larval stage. Eggs of inshore species are often enveloped in a gelatinous matrix attached to substrate, while the eggs of offshore species are extruded as drifting masses. Eggs are laid on the bottom on the upper slope (200 to 800 m) and incubate for 1 to 2 months. Young juveniles are distributed pelagically (less than 100 m depth) from the coast to the open ocean. Older juveniles and adults are distributed mesopelagically (150 to 500 m deep) on the shelf, but predominate in the shelf/slope areas. Adults migrate to slope waters to mate and spawn demersally. The red armhook squid appears to spawn in the spring and to live as long as 4 years, though most die after spawning at 1 year to 16 months (Arkhipkin et al. 1996). Perez (1990) estimated that squid comprise over 80 percent of the diet of some whales. Seabirds and some salmon species are also known to feed heavily on squid at certain times of the year.

Assessment data are not available for squid from NMFS surveys because of their mainly pelagic distribution over deep water. Information on the distribution, abundance, and biology of squid stocks in the EBS and AI is generally lacking. Red armhook squid (*Berryteuthis magister*) predominates in commercial catches in the EBS and GOA and is distributed in the boreal North Pacific from California, throughout the EBS, to Japan in waters from 30 to 1,500 m deep. *Onychoteuthis borealijaponicus* is the principal species encountered in the AI. It is distributed in the North Pacific from the Sea of Japan, throughout the AI, and south to California, but is absent from the Sea of Okhotsk and is not common in the EBS. *Moroteuthis robusta*, a giant squid, lives near the bottom of the slope and mesopelagically over abyssal waters. This squid is rarely found on the continental shelf. It is distributed in all oceans and is found in the EBS, AI, and the GOA. *Rossia pacifica* is a small demersal neritic and shelf boreal species that is distributed from Japan to California in the North Pacific and in the EBS in waters from 20 to 300 m deep.

The principal prey items of squid are small forage fish, pelagic crustaceans such as euphausiids and shrimp, and other cephalopods; cannibalism is not uncommon. As young juveniles, squid eat small planktonic copepods. Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent, by fish; steelhead and coho and chinook salmon eat squid when foraging on the high seas. Perez (1990) estimated that squid comprise over 80 percent of the diet of sperm whales, bottlenose whales, and beaked whales, as well as approximately half the diet of Dall's porpoise in the EBS and AI. Seabirds (kittiwakes, puffins, and murres) on island rookeries close to the shelf break (Buldir Island, Pribilof Island) are also known to feed heavily on squid (Hatch et al. 1990, Byrd et al. 1992, Springer 1993). In the GOA, only 5 percent or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

Many species of squid are important prey for marine mammals and birds, as well as commercial groundfish species. Squid are consumed primarily by marine mammals such as Steller sea lions (Lowry et al. 1982), northern fur seals (Perez and Bigg 1986), harbor seals (Lowry et al. 1982, Pitcher 1980b), sperm whales (Kawakami 1980), Dall's porpoise (Crawford 1981), Pacific white-sided dolphins (Morris et al. 1983), and beaked whales (Loughlin and Perez 1985).

3.2.4.3.2 Sculpins

Forty-one sculpin species were identified in the EBS, and 22 species were identified in the Aleutian Islands (Bakkala 1993, Bakkala et al. 1985, Ronholt et al. 1985) during U.S.-Japan surveys in the EBS and AI in the 1980s. The Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the North Pacific Ocean. Most species live in shallow water or in tidepools, but some inhabit deeper waters (to 1,000 m) of the continental shelf and slope. Most species grow to 10 to 15 cm, but those that live on the continental shelf and are caught by fisheries can be 30 to 50 cm. Most sculpin spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs against rocks where they are guarded by males. Egg incubation duration is unknown. Larvae are found across broad areas of the shelf and slope and are present year-round in collections from the southeast BS and the GOA. Larvae exhibit diel vertical migration (near the surface at night and at depth during the day). Sculpins generally eat small invertebrates such as crabs, barnacles, and mussels, but fish are included in the diet of larger sculpin species. Larvae eat copepods. Sculpins have also been found in the diet of harbor seals (Lowry et al. 1982).

3.2.4.3.3 Skates

Skate species that have been consistently identified during surveys are the Alaska skate (*Bathyraja parmifera*), big skate (*Raja binoculata*), longnose skate ®. *rhina*), starry skate ®. *stellulata)*, and Aleutian skate (*B. aleutica*). During U.S.-Japan surveys in the 1980s, 15 skate species were identified, but inadequate taxonomic keys for this family may have resulted in more species being identified than actually exist. Skates that occur in the BSAI and GOA are grouped into two genera: *Bathyraja*, or soft-nosed species and *Raja*, or hard-nosed species. Skates are oviparous, fertilization is internal, and eggs are deposited in a horny case for incubation. After hatching, juveniles likely remain in shelf and slope waters, but distribution is unknown. Adults and juveniles are demersal and feed on bottom invertebrates and fish. Data from surveys indicate that Alaska skates are most common from 50 to 200 m deep on the continental shelf in the EBS and the AI and are less common in the GOA. The Aleutian skate is distributed throughout the EBS and the AI, but is less common in the GOA, and is found primarily between 100 and 350 m. The Bering skate is found throughout the EBS and the GOA, primarily between

100 to 350 m, but is less common in the AI. Little is known of the habitat requirements for these species for growth or reproduction, and no data are available on their seasonal movements.

3.2.4.3.4 Sharks

Spiny dogfish are widely distributed through the Atlantic, Pacific, and Indian oceans. In the North Pacific, these species may be most abundant in the GOA, but are also common in the EBS. Spiny dogfish are a pelagic species, found at the surface and down to depths of 700 m. Most commonly, they are found up to 200 m deep on the continental shelf. These species are often found in aggregations. Females give birth in shallow coastal waters, usually from September to January. Dogfish eat a wide variety of food including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Tagging experiments indicate local, indigenous populations in some areas and widely migrating groups in other areas. Spiny dogfish may move inshore in summer and offshore in winter.

The Pacific sleeper shark is distributed from California around the Pacific Rim to Japan and the EBS. This species occurs principally on the outer shelf and upper slope, but has also been seen nearshore. Pacific sleeper shark are generally demersal, but have also been seen near the surface. Fertilization and development of sleeper sharks are not known. Pacific sleeper sharks are voracious, omnivorous predators of flatfish, cephalopods, rockfish, crabs, seals, salmon, and may also prey on pinnipeds. Distribution in the survey area has been observed chiefly on outer shelf/upper slope areas in the EBS, but nearshore to the outer shelf in the GOA, particularly near Kodiak Island.

Salmon sharks are distributed epipelagically along the continental shelf. They can be found in shallow waters from California through the GOA, the EBS, and off Japan. These sharks have been found mostly on the outer shelf/upper slope areas in the EBS, but from nearshore areas to the outer shelf in the GOA, particularly near Kodiak Island and in Prince William Sound. Salmon sharks are not commonly seen in the AI. Sharks are believed to eat primarily fish, including salmon, sculpins, and gadids. Females likely give birth in offshore pelagic areas.

3.2.4.3.5 Octopi

Octopi are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. In the BSAI and GOA, the most commonly encountered octopods are the shelf demersal species *Enteroctopus dofleini*, and the bathypelagic species *Vampyroteuthis infernalis*. Octopods, like other cephalopods, are dioeceous, with fertilization of eggs requiring transfer of spermatophores during copulation. Octopods usually do not live longer than 2 to 4 years. *E. dofleini*, the giant octopus, is distributed in the southern boreal region from Japan and Korea, through the AI, GOA, and south along the Pacific coast of North America to California. This species inhabits the sublittoral to upper slope regions. Mating for this species likely occurs in late fall and winter, but oviposition occurs the following spring. *V. infernalis* lives at depths well below the thermocline and is most commonly found at 700 to 1,500 m depth. This species is found throughout the oceans of the world. Little is known of their food habits, longevity, or abundance.

3.3 Ecosystem Considerations

An ecosystem is a spatially explicit area that includes all organisms and components of the abiotic environment within its boundaries. Two large marine ecosystems have been identified off Alaska: the BSAI and the GOA. These two areas have distinct geographic and biological features. These ecosystems and their features are briefly described in this section; additional detail can be found in the Alaska Groundfish Fisheries Revised Draft Programmatic SEIS (NMFS 2003a).

Three natural processes underlie changes in population structure of species in marine ecosystems: competition, predation, and environmental disturbance. Natural variations in recruitment, survivorship, and growth of fish stocks are consequences of these processes. Competition is a process basic to many ecological theories; it requires an assumption that species in an ecosystem are limited in their access to critical resources such as food, space, mates, and time for important activities. Another process, predation, is also important as it changes prey density, thereby directly or indirectly affecting populations throughout the ecosystem. Environmental disturbances induced by climatic change do occur in the North Pacific Ocean (Francis and Hare 1994), and such disturbances have been proposed as major structuring processes in these ecosystems. Climate has the potential to influence the important biological processes of reproduction, growth, consumption/predation, movement, and, ultimately, the survival of marine organisms.

Human activities, such as commercial fishing, can also influence the structure and function of marine ecosystems. Fishing, a subset of predation which can also cause environmental disturbance, has the potential to influence ecosystems in several ways (Jennings and Kaiser 1998). It may alter the amount and flow of energy in an ecosystem by removing energy and changing energetic pathways through the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Selective removal of particular species and certain sizes of organisms has the potential to change predator-prey relationships and community structure. Introduction of non-native species to the marine ecosystem has the potential to cause significant changes in community dynamics. Species introductions may have occurred off Alaska through emptying of ballast water contained in ships entering Alaska waters from other regions, which may have been oil tankers, fishing vessels, or other types of ships. Fishing can alter different measures of diversity. Species level diversity, or the number of species, can be altered if fishing essentially removes a species from the system; however, there is no evidence that fishing has reduced the number of species present in Alaska waters. Fishing can alter functional or trophic diversity if it selectively removes a trophic guild member and changes the evenness with which biomass is distributed among a trophic guild. Certain species, such as pollock, are at a central position in the food web, and their abundance is an indicator of prey availability for many predator species. Fishing can alter genetic level diversity by selectively removing faster growing fish or removing spawning aggregrations that might have different genetic characteristics than other spawning aggregations. Fishing gear can alter bottom habitat and damage benthic organisms and communities.

Ecosystem-based management strategies for fisheries are being developed around the world to address the larger impacts due to fishing. Ecosystem-based fishery management aims at conserving the structure and function of marine ecosystems, in addition to conserving target fish species. An ecosystem-based management strategy for marine fisheries is one that minimizes potential impacts while at the same time allowing the extraction of fish resources at levels sustainable for both the fish stock and the ecosystem. In 1997, a NMFS Ecosystem Principles Advisory Panel (the Panel) was appointed to report to Congress on the extent to which ecosystem principles are applied in fishery conservation and management, including research, and to propose actions that should be undertaken to expand the application of ecosystem principles in fishery conservation and management. The Panel's report provided updated information on ecosystem-based management of fisheries (NMFS 1999). The Panel described ecosystem-based management for marine fisheries:

> Ecosystem-based management can be an important complement to existing fisheries management approaches. When fishery managers understand the complex ecological

and socioeconomic environments in which fish and fisheries exist, they may be able to anticipate the effects that fishery management will have on the ecosystem and the effects that ecosystem change will have on fisheries. However, ecosystem-based management cannot resolve all of the underlying problems of the existing fisheries management regimes. Absent the political will to stop overfishing, protect habitat, and support expanded research and monitoring programs, an ecosystem-based approach cannot be effective.

A comprehensive ecosystem-based fisheries management approach would require managers to consider all interactions that a target fish stock has with predators, competitors, and prey species; the effects of weather and climate on fisheries biology and ecology; the complex interactions between fishes and their habitat; and the effects of fishing on fish stocks and their habitat. However, the approach need not be endlessly complicated. An initial step may require only that managers consider how the harvesting of one species might impact other species in the ecosystem. Fishery management decisions made at this level of understanding can prevent significant and potentially irreversible changes in marine ecosystems caused by fishing.

In 1999, the National Research Council (NRC), an agency organized by the National Academy of Sciences, set out new performance standards for fishery management in *Sustaining Marine Fisheries* (NRC 1999a). The publication reviews the status of global fisheries, examines the problems facing fishery managers, and provides recommendations on how to improve management to achieve sustainable marine fisheries. NRC's overall recommendation was adoption of an ecosystem-based approach for fishery management with the goal "to rebuild and sustain populations, species, biological communities, and marine ecosystems at high levels of productivity and biological diversity, so as not to jeopardize a wide range of goods and services from marine ecosystems, while providing food, revenue, and recreation for humans" (NRC 1999a). To achieve an ecosystem-based approach, the NRC made eight specific recommendations, as shown to the right.

Recommended measures to achieve an ecosystem-based management approach

1. Adopt conservative harvest levels for single species fisheries.
2. Incorporate ecosystem considerations into fishery management decisions.
3. Adopt a precautionary approach to deal with uncertainty.
4. Reduce excess fishing capacity and define and assign fishing rights.
5. Establish marine protected areas as a buffer for uncertainty.
6. Include bycatch mortality in TAC accounting.
7. Develop institutions to achieve goals.
8. Conduct more research on structure and function of marine ecosystems.

The management measures implemented for Alaska groundfish fisheries generally achieve all of the measures recommended by the NRC, so current fishery management policies can be considered an ecosystem-based approach. A review of management measures implemented for Alaska groundfish fisheries to reduce ecosystem impacts is provided by Witherell et al. (2000). An evaluation of how well the status quo groundfish management regime achieves ecosystem-based management policies is contained in the draft programmatic groundfish SEIS (NMFS 2001a). The current management regime provides for conservative harvest limits, incorporation of ecosystem considerations, a precautionary approach for uncertainty, limited access to reduce fishing capacity, marine protected areas for sensitive habitat, inclusion of bycatch mortality into catch accounting, coordination with other agencies, and ecosystem research through NMFS, universities, ADF&G, and other agencies.

3.3.1 Bering Sea and Aleutian Islands Ecosystem

The Bering Sea is a semi-enclosed, high-latitude sea. Of its total area of 2.3 million sq. km, 44 percent is continental shelf, 13 percent is continental slope, and 43 percent is deep water basin. Its broad continental shelf is one of the most biologically productive areas of the world. In contrast, the AI shelf is very narrow. A special feature of the EBS is the pack ice that covers most of its eastern and northern continental shelf during winter and spring. The dominant circulation of the water begins with the passage of North Pacific water (the Alaska Stream) into the EBS through the major passes in the AI (Favorite et al. 1976). There is net water transport eastward along the north side of the AI and a turn northward at the continental shelf break and at the eastern perimeter of Bristol Bay. Eventually EBS water exits northward through the Bering Strait, or westward and south along the Russian coast, entering the western North Pacific Ocean via the Kamchatka Strait. Some resident water joins new North Pacific water entering Near Strait, which sustains a permanent gyre around the deep basin in the central BS.

The EBS contains about 300 species of fish, 150 species of crustaceans and molluscs, 50 species of seabirds, and 26 species of marine mammals (Livingston and Tjelmeland 2000). Nevertheless, diversity of commercial fish species is lower than in the GOA. Groundfish species that are the target of EBS fisheries include pollock, cod, sablefish, Atka mackerel, and several species of flatfish, including arrowtooth,, rock sole, flathead sole, rex sole, and Dover sole. Pacific halibut, targeted in longline fisheries, is widely distributed in the EBS. Squid, sharks, sculpins, and salmon are also found along the shelf, as well as forage species such as herring, sand lance, and capelin (Bakkala 1993). Large invertebrates subject to fishing on the shelf include red king crab, blue king crab, snow crab, and Tanner crab, as well as golden king crab on the continental slope. Many species of erect epifauna occur here, with corals and sponges found in abundance throughout the AI.

The EBS supports some of the largest commercial fisheries in the world. The biological and oceanographic dynamics of this region have been monitored for trends and potential sources of problems, such as overfishing or fishery-induced declines in species not targeted by these fisheries. Livingston et al. (1999) reviewed the trends in the fisheries and potential impacts to the EBS ecosystems. Historical biomass trends of three different trophic guilds in the EBS were examined to see if there was a relationship between fishing or climate and changes in total guild biomass or changes in species in the guild. For example, large fishing removals of one guild species might result in increases in other members of that guild as competitive pressures ease. Similarly, if fishing removes large numbers of a prey important to all members of the guild, an overall decrease in abundance of the guild species might be observed, as well as decreased mean size at age of predators relying on that prey. Alternatively, if the factor inducing observed change were environmental, trends in mean size at age or abundance that correlate positively or negatively with temperature or other climate factors might be seen (Figure 3.3-1).

Livingston et al. (1999) found that, despite conservative exploitation rates, a variety of species in diverse trophic groups showed either long-term increases or decreases in abundance (e.g., arrowtooth flounder, Greenland halibut, some seabirds, and marine mammals), while both fished and unfished species have shown cyclic fluctuations in abundance over the last two decades (pollock, cod, crab, and sea stars, among others). There appeared to be no link between species declines and prey abundance. The timing of some species declines, such as marine birds, was more related to increases in the adult populations of their main prey species, pollock. Similarly, the timing of increases in some guild member biomasses did not relate to fishing intensity of other guild members (e.g., skate and cod). However, this study did not consider spatial changes in prey abundance or availability that could occur. Environment was linked to the recruitment of some guild members, and decreases in individual growth of some species (rock sole) were linked to increases in rock sole biomass. Diversity changes in some trophic guilds were related to increases in a dominant guild member (e.g., pollock in the pelagic fish consumer guild and rock sole in the benthic infauna consumer guild) rather than to fishing-induced changes in diversity. Study results also show a stable trophic level of catch and stable populations overall. The trophic level of the EBS harvest has risen slightly since the early 1950s, and appeared stable as of 1994.

Other studies have also linked production, recruitment, or biomass changes in the EBS with climate factors. For example, the large increase in gelatinous zooplankton in the EBS has been linked to a climate regime change that might have occurred around 1990 (Brodeur et al. 1999). Recruitment in both crabs and groundfish in the EBS has been linked to climate factors (Zheng and Kruse 1998, Rosenkranz et al. 1998, Hollowed et al. 1998, Hare and Mantua 2000). Several studies indicate that the EBS ecosystem responds to decadal oscillations and atmospheric forcing and that the 1976-1977 regime shift had pronounced effects there (Francis et al. 1999, Hare and Mantua 2000). Chlorophyll concentrations did show a peak in the late 1970s, which was closely related to the increase in summer mixed-layer stability (Sugimoto and Tadokoro 1997).

3.3.2 Gulf of Alaska Ecosystems

The GOA is characterized by a narrow continental shelf with a total shelf area of about 160,000 sq. km, which is less than 25 percent the size of the EBS shelf. The GOA is a more open marine ecosystem, with land mass to the east and north. The dominant circulation in the GOA is characterized by the cyclonic flow of the Alaska gyre. Large seasonal variations in the wind-stress curl in the GOA affect the meanders of the Alaska Stream and nearshore eddies. The variations in these nearshore flows and eddies affect much of the region's biological variability.

Diversity of commercial bottomfish species in the GOA is intermediate between those of the EBS, where fewer species occur, and the Washington-California region, where more species are present (Figures 3.3-2, 3.3-3, and 3.3-4). The most diverse set of species in the GOA is the rockfish group (genus *Sebastes*), 30 species of which have been identified in this area. Other groundfish that are the target of fisheries in the GOA include pollock, cod, sablefish, Atka mackerel, and several species of flatfish, including arrowtooth, Pacific halibut, rock sole, flathead sole, rex sole, and Dover sole. Squid, sharks, sculpins, and salmon are also found along the shelf, as well as forage species such as herring, sand lance, and capelin. Along the slope of the continental shelf, rattails and thornyhead rockfish are larger components of the groundfish community. Large invertebrates subject to fishing include several species of scallops, crabs, sea urchins, sea cucumbers, and clams. Corals, sponges, and many other invertebrates are found throughout the shelf and continental slope.

Mueter (1999) examined GOA groundfish communities using groundfish and shrimp trawl data collected over several years from the eastern and western GOA (Figure 3.3-5). The data were analyzed for species richness, diversity, total abundance, and indices of species composition as they related to depth, temperature, salinity, sediment composition, geographic location, and time of sampling to identify spatial and temporal patterns in community structure. The data were then compared to local and larger scale atmospheric and oceanographic changes. In general, species richness and diversity peaked at water depths of about 200 to 300 m in the GOA. Higher abundance, lower species richness and diversity, and a different species composition of demersal fishes were found in the western GOA compared with the eastern GOA. These large-scale spatial patterns were related to upwelling differences between the two regions. The lowest species richness (number of species per haul) was observed in 1984 while the lowest species diversity (as measured by the Shannon-Wiener diversity index) was seen in 1996. It is difficult to tell whether these trends are real because of changes in trawl survey techniques and gear used in different years. General increases in total groundfish biomass were seen from 1984 to 1996, coupled with significant changes in species composition.

The total groundfish biomass assessed in bottom trawl surveys in shelf and slope areas increased between 1984 and 1996, despite a considerable, concurrent increase in harvest effort. During the same period, the abundances of unexploited (or underexploited) species, including skate, some shark species, forage species, arrowtooth flounder, and other flatfishes, also increased (Mueter 1999). Populations of an overexploited species, the Pacific ocean perch, also rebounded from low population levels. However, total groundfish biomass since that time appears to be declining (Council 2000b). The controlling factor for these changes appears to be environmental, with changes in the species composition in nearshore areas linked to an increase in advection in the Alaska Coastal Current. Increased flow around the GOA may enhance the supply of nutrients and plankton on the shelf and upper slope areas, resulting in an increase in productivity during certain flow regimes.

The effects of 10-year regime shifts on the inshore GOA were analyzed using data from 1953 to 1997 (Anderson and Piatt 1999). Three taxonomic groups dominated (approximately 90 percent) the biomass of commercial catches during this period: shrimp, cod and pollock, and flatfish. When the Aleutian low was weak, resulting in colder water, shrimp dominated the catches. When the Aleutian low was strong, water temperatures were higher, and the catches were dominated by cod, pollock, and flatfish. Similar results were reported in very nearshore areas of lower Cook Inlet (Robards et al. 1999).

Few patterns were seen in the less-common species over the course of the study (Robards et al. 1999). Generally, the transitions in dominance lagged behind the shift in water temperature, strengthening the argument that the forcing agent was environmental. However, different species responded to the temperature shift with differing time lags. This was most evident for species at higher trophic levels, which are typically longer-lived and, thus, take more time to exhibit the effects of changes. The evidence suggests that the inshore community was reorganized following the 1977 climate regime shift. Although large fisheries for pandalid shrimp may have hastened the decline for some stocks (Orensanz et al. 1998), unfished or lightly fished shrimp stocks also showed declines. Both Orensanz et al. (1998) and Anderson and Piatt (1999) concluded that the large geographic scale of the changes across so many taxa is a strong argument that climate change is responsible.

3.4 Human Activities

3.4.1 Magnuson-Stevens Act Managed Fisheries

NMFS manages most groundfish fisheries off the Alaska coast under federal FMPs recommended by the Council and approved by the Secretary of Commerce. A review of the federally managed fisheries and the management program is provided in this section.

3.4.1.1 GOA Groundfish Fisheries

3.4.1.1.1 Summary of the GOA Groundfish FMP

The GOA Groundfish FMP was implemented on December 1, 1978. The FMP has been amended more than 70 times. The plan encompasses that portion of the GOA within the 3- to 200-mile EEZ between 132°40' W and 170° W. This area is divided into three regulatory areas: eastern (132°40' W to 147° W), central (147° W to 159° W), and western (159° W to 170° W). The plan covers all domestic fisheries for all finfish except salmon, steelhead trout, halibut, herring, and tuna in the GOA. The primary objectives of the plan are to promote conservation while providing for optimum yield, promote efficient use of fishery resources, promote fair resource allocation, and use the best scientific data available in making management decisions. To accomplish these objectives, a large suite of management measures and regulations has been adopted. Management measures include catch limits, permit requirements, prohibited species, marine mammal conservation measures, fishing area restrictions, gear restrictions, reporting requirements, observer program, effort limitation programs, community development quota programs, inseason adjustments, gear allocations, inshore/offshore allocations, retention and utilization requirements, experimental fishing permits, and other measures. Current fishery regulations can be viewed and downloaded from the NMFS Alaska Region website: www.fakr.noaa.gov.

Fisheries regulations of the FMP apply to five categories of species or species groups that are likely to be taken in the groundfish fishery. The optimum yield concept is applied to all except the "prohibited species" category. These categories are described as follows:

1. Prohibited species are those species and species groups the catch of which must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species groups under this FMP for which the quotas have been achieved must be treated in the same manner as prohibited species. Prohibited species include Pacific halibut, Pacific herring, salmonids, king crab, and Tanner crab. A prohibited species catch limit for halibut is established for trawl and fixed gear fisheries.

2. Target species are commercially important and are generally targeted upon by the groundfish fishery. Sufficient data exist to specify TAC and to manage each species or species group separately. Catch records must be kept. Target species include pollock, Pacific cod, Atka mackerel, and sablefish, as well as numerous species of rockfish and flatfish.

3. Other species have little current economic value and are not usually targeted upon, but they may be significant components of the ecosystem or have economic potential. A single TAC applies to this category as a whole. Catch records must be kept. Other species include sculpins, sharks, skates, and octopus.

4. Forage fish species are species that are a critical food source for marine mammals, seabirds, and fish species. Forage fish species include smelts, lantern fish, sandfish, gunnels, krill, etc.

5. Nonspecified species are those species and species groups of no current economic value taken by the groundfish fishery only as an incidental catch in the target fisheries. Non-specified species include numerous fish and invertebrates such as grenadiers, eelpouts, sea urchins, mussels, etc. No record of catch is necessary, and no TAC is established for this category.

A brief overview of management measures is provided below.

Catch limits: Catch limits (TACs) are established for target species or species groups. The sum of TACs for all target and other species must fall within the optimum yield (OY) range established for the GOA groundfish complex (116,000 to 800,000 mt).

Permit requirements: All vessels fishing in the federal GOA management area, or receiving fish from this area, must have a current fishing permit.

Prohibited species: Regulations have been implemented to control the incidental bycatch and injury of prohibited species (salmon, halibut, red king crab, Tanner crab, snow crab, and herring). Regulatory measures have included trawl closure areas, bycatch limits, gear regulations, and careful release requirements. An incentive program to reduce bycatch rates of prohibited species is authorized under the FMP.

Marine mammal and seabird conservation measures: Steller sea lion protection measures imposed in fisheries for Pacific cod and pollock include restrictions on fishing activity in critical habitat (including no-fishing zones around rookeries and haulouts) and measures designed to disperse fishing activity in time and space over the year. The dispersion measures are meant to decrease the chance of localized depletion of prey for Steller sea lions. Hook-and-line groundfish and halibut fishermen are required to use gear devices and fishing methods to reduce bycatch of seabirds. To protect Steller sea lions, no trawling is allowed year-round within 10 nm of Steller sea lion rookeries. In addition, some of these rookery no-trawl closure areas seasonally extend out to 20 nm. Beginning in 1999, trawling for pollock has been prohibited around numerous haulout areas. Multiple pollock fishery seasons were instituted explicitly to prevent pollock fisheries from becoming temporally compressed, thereby decreasing the chance of localized depletion of prey for Steller sea lions. There is also a prohibition on commercial exploitation of forage fish species such as capelin, sand lance, and smelt, which are eaten by various marine mammals and seabirds.

Fishing area restrictions: Area restrictions have been implemented to control bycatch of prohibited species and to protect sensitive benthic habitat from potential impacts due to fishing. Areas may be off limits to certain gear types or to all gear types. For example, bottom trawling is prohibited in Cook Inlet year-round to protect crab habitat, and Southeast Alaska is closed to all bottomfish trawls with the following exception: a small beam-trawl shrimp fishery takes place in Southeast Alaska inside waters.

Gear restrictions: Gear restrictions are made for conservation and management of fishery resources. The FMP authorizes the use of trawls, hook-and-line, pots, jigs, and other gear types as defined in regulations.

Reporting requirements: Recordkeeping and reporting requirements have been implemented to keep track of fishing effort, landings, processing, and transfers. Processors are required to file an annual notice of intent to operate with ADF&G and must complete and submit fish tickets documenting purchases from catcher vessels. Operators of catcher vessels that sell fish at dockside must also file fish tickets as catcher-sellers. Catcher-processor and mothership-processor vessel operators are required to have a federal permit, must complete a NMFS weekly production report (WPR), and may also voluntarily submit fish tickets. Shoreside processors must also file a WPR or participate in an electronic reporting system. In addition, all processors are now required to complete an ADF&G Commercial Operators Annual Report. There are numerous other requirements for recordkeeping and reporting to ensure timely and effective in-season management of bycatch and individual groundfish stocks.

Observer program: A domestic observer program was implemented beginning with the 1990 fishing year. Observers collect biological and catch and discard information. All vessels capable of hosting an observer may be required to do so at the host vessel's expense. As currently implemented, vessels more than 125 feet in length overall (LOA) are required to have an observer on-board at all times when participating in the groundfish fishery, vessels of 60 to 124 feet LOA are required to have observers on-board 30 percent of the time when groundfish fishing, and vessels under 60 feet LOA are generally exempt from the requirements for observer coverage.

Effort limitation programs: In 1995, a moratorium on entry of new vessels into the groundfish fishery was implemented. The increasingly large number of vessels fishing for a limited resource had created a "race for fish," characterized by short seasons and economic inefficiency. Although a moratorium did not resolve the underlying problems of existing overcapitalization and excess effort in the groundfish fisheries, the intent of the moratorium was to prevent these problems from worsening while comprehensive solutions were being developed. The eligibility period for moratorium qualification was January 1, 1988, through February 9, 1992, during which time a vessel must have made at least one legal landing of groundfish. In June 1995, Council adopted a license limitation program as Amendment 39 to supersede the vessel moratorium. The license limitation program was implemented in 2000. Beginning in 1995, an IFQ program was implemented to manage the fixed gear halibut and sablefish fisheries.

Seasonal allocations and inseason adjustments. Harvest allocations and management are based on the calendar year. Fishing seasons for specific species or gear types may be set by regulatory amendment and may differ from the fishing year. For example, hook-and-line sablefish fisheries began on March 1 in 2003. All trawl fisheries are delayed until January 20. Trawl fisheries also open and close based on seasonal allocation of halibut and crab bycatch limits. The season for hook-and-line gear for Pacific cod can be closed because of halibut bycatch limits.

Gear allocations: Some TACs have been allocated to vessels using particular gear types. Sablefish in the western and central GOA is allocated 80 percent to hook-and-longline gear and 20 percent to trawl gear; in the eastern GOA, sablefish is allocated 95 percent to hook-and-line gear and 5 percent to trawl gear.

Inshore/offshore allocation: The pollock TAC in the GOA was allocated 100 percent to the inshore sector of the fishery beginning in 1992. For Pacific cod, 90 percent of the TAC is allocated to the inshore sector and 10 percent to the offshore sector.

Retention and utilization requirements: The practice of roe-stripping of pollock (defined as the taking of roe from female pollock and the subsequent discard of the carcasses of females and all male pollock) has been prohibited. Full retention of all pollock and Pacific cod caught in all GOA fisheries was required beginning on January 1, 1998.

Exempted fishing permits: The FMP authorizes the NMFS Regional Administrator to issue exempted fishing permits for limited experimental purposes that allow the harvest of groundfish that would otherwise be prohibited. Exempted fishing permits might be issued for fishing in areas closed to fishing, for continued fishing with gear otherwise prohibited, or for continued fishing for species for which the quota has been reached.

Habitat protection measures: The FMP authorizes the establishment of regulations to manage fishing or fishing vessels for habitat reasons. Reasons include 1) protecting habitat by establishing gear, timing, or area restrictions; 2) preventing the commercial harvest of important forage fish; 3) preventing the harvest of fish in contaminated areas; and 4) restricting the disposal of fishing gear.

3.4.1.1.2 Description of the Fisheries and Gears

3.4.1.1.2.1 GOA Pollock Trawl Fishery

Description of gear used: This fishery is prosecuted with primarily pelagic otter trawls rigged to fish for schooling pollock. Vessels participating in this fishery are shore-based catcher vessels from 58 to 125 feet long and ranging from 350 to 1,600 horsepower (hp). The gear includes primarily large mesh mid-water trawls (Figure 3.4-1) and, to a limited extent, bottom trawls (Figure 3.4-2).

Mid-water pelagic trawls typically have a headrope to footrope vertical distance "rise" of 7 to 30 fathoms and a horizontal opening of 12 to 60 fathoms (wing-end spread of 18 to 80 fathoms). Typical sizes are 20 fathoms vertical and 40 fathoms horizontal and 60 fathoms wing-end spread for vessels with an average 1,000 hp. Wing-end spread is typically 15 percent greater than horizontal opening size. To achieve these large openings with a minimum of drag, the mesh sizes are very large, and twine size is relatively small. Front meshes of a large mid-water net may be as large as 120 feet. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5-inch stretched mesh.

Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 3 up to 7 sq. m. Door spread in most fishing depths and trawl warp/scope combinations is typically 100 to 180 m. Contact with the seafloor, when it occurs, is typically from the weight chains attached to the wing ends and/or the center section of the footrope. Long wire rope bridles attach the net to the doors. Unlike other groundfish trawl fisheries, there are no discs attached to the footropes on these trawls.

Different types of bottom trawls are used, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 90 to 120 feet. Wing-end spread is typically 12 fathoms with a 120-foot footrope. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5.5-inch stretched mesh, hung either square or diamond. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 2.5 to 6 sq. m, with a typical horizontal length of 6 to 9 feet and a typical angle of attack of 30 to 36º. High aspect doors have a typical horizontal length of 2 to 4 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less of the horizontal length of the door. Sweeps are typically 45 fathoms at 11 to 15º. Contact with the seafloor is from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Trawls may be fitted with sonar systems designed to monitor net performance remotely. These third wire systems may improve catching efficiency and help vessel operators avoid net damage.

A bottom trawl with a headrope length of 90 feet and footrope length of 120 feet weighs approximately 1,800 pounds.

Additional gear adds to the weight. A 14-inch rockhopper disc weighs approximately 2,800 pounds (750 pounds of steel components and 2,100 pounds of rubber components) and the headrope floats weigh 700 to 800 pounds. Hydrodynamic effects contribute to reduced downward force.

<u>Description of fishery operations</u>: Sets are made on pollock schools as indicated by acoustic sensors mounted on the net or the vessel's hull. When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out, and the winches are tightened. Tow duration in this fishery is typically 3 hours, ranging from 30 minutes to 12 hours depending upon catch rates, at a speed of 2.5 to 4 knots. Typically, this is done two to three times a day with the number of tows depending on catch rates. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of 'hangs' and fixed gear. They may also be pushed by current, or for other reasons. Quite often, vessels will turn around 180º while towing, making several passes in the same general area. The rough substrate in the GOA would damage mid-water nets, creating an incentive to avoid touching the bottom. In addition, the characteristics of the narrow shelf create conditions where the pollock are often found up in the water column. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

The fishery occurs in four quarterly seasons and is further broken out into five separate management areas. There are standdown periods of no fishing between the quarterly seasons. Catch rates are generally higher during the winter roe season due to spawning aggregations. There are currently significant closed areas due to Steller sea lion protection measures which have altered fishing. The fishery has also changed over time due to state water closures to nonpelagic nets, inshore/offshore allocations, Steller sea lion mitigation measures, the American Fisheries Act, and gradual increases in fishing capability.

3.4.1.1.2.2 GOA Pacific Cod Trawl Fishery

Description of gear used: The inshore fishery is prosecuted by nonpelagic bottom trawls (Figure 3.4-2). Vessels participating in this fishery are shore-based catcher vessels from 58 to 125 feet and ranging from 350 to 1,600 hp. The gear used includes many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 90 to 120 feet. Wing-end spread is typically 12 fathoms with an 120-foot footrope. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5.5- to 8-inch stretched mesh, hung either square or diamond. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 2.5 to 6 sq. m with a typical horizontal length of 6 to 9 feet and a typical angle of attack is 30 to 36º. High aspect doors have a typical horizontal length of 2 to 4 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less of the horizontal length of the door. Sweeps are typically 45 fathoms at 11 to 15º. Contact with the seafloor is primarily from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

The offshore fishery is prosecuted by nonpelagic bottom trawls. Vessels participating in this fishery are catcher-processors between 98 and 200 feet LOA, with 900 to 3,500 hp. The gear used includes many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 120 to 190 feet. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5.5- to 8-inch stretched mesh, hung either square or diamond. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 5.5 to 9 sq. m with a typical horizontal length of 9 to 12 feet and a typical angle of attack is 30 to 36º. High aspect doors have a typical horizontal length of 4 to 8 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less of the horizontal length of the door. Door spread is typically 45 fathom sweeps at 11 to 15º. Contact with the seafloor is primarily from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Trawls may be fitted with sonar systems designed to monitor net performance remotely. These third wire systems may improve catching efficiency and help vessel operators avoid net damage.

A bottom trawl with a headrope length of 90 feet and a footrope length of 120 feet weighs approximately 1,800 pounds. Additional gear adds to the weight. A 14-inch rockhopper disc weighs approximately 2,800 pounds (750 pounds of steel components and 2,100 pounds of rubber components) and the headrope floats weigh 700 to 800 pounds. Hydrodynamic effects contribute to reduced downward force.

Description of fishery operations: Sets are made on cod schools as indicated by electronics. Fishing predominantly occurs during daylight hours. When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out, and the winches are tightened. Tow duration in this fishery is variable, ranging from 1 to 4 hours depending upon catch rates, at a speed of 2.5 to 4 knots. Typically, this is done two to three times a day with the number of tows depending on catch rates. Catcher-processors may occasionally make more tows per day to keep on-board factories operating. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid hangs and fixed gear. They may also be pushed by current, or for other reasons. Quite often, vessels will turn around 180º while towing, making several passes in the same general area. The rough substrate in the GOA damages nets, creating an incentive to avoid rough bottom. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

The fishery occurs in two seasons and is further broken out into four separate management areas. There is no directed fishing for cod from November 1 to January 20, and there is no directed fishing between the two seasons. Catch rates are generally higher during the winter due to spawning aggregations. There are currently significant numbers of closed areas due to Steller sea lion protection measures, which have altered fishing. The fishery has also changed over time due to state water closures to nonpelagic nets, management of a state water Pacific cod fishery, inshore/offshore allocations, Steller sea lion mitigation measures, the American Fisheries Act, and gradual increases in fishing capability.

3.4.1.1.2.3 GOA Deepwater Flatfish Trawl Fishery

Description of gear used: Target species for this fishery include rex sole, Dover sole, arrowtooth flounder, and other deepwater flatfish. This fishery is prosecuted by bottom trawls (Figure 3.4-2). Vessels participating in this fishery are shore-based catcher vessels from 58 to 125 feet and ranging from 350 to 1,600 hp. Typically fewer than 20 vessels participate in this fishery.

Catcher vessels use many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 90 to 120 feet. Wing-end spread is typically 12 fathoms with a 120-foot footrope. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 4.5- to 5-inch stretched mesh, hung either square or diamond. Codends have sacrificial 'chafing gear' (usually polyethylene fiber) attached to the bottom and sides to protect them from damage from contact with the sea floor and damage occurring during retrieval up the stern ramp. Otter boards or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 2.5 to 6 sq. m with a typical horizontal length of 6 to 9 feet and typical angle of attack of 30 to 36º. High aspect doors have a typical horizontal length of 2 to 4 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less the horizontal length of the door. Door spread is typically 60 to 100 fathom so that the doors and sweeps perform at 11 to 13º. Contact with the seafloor is from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Catcher-processors also participate in this fishery with bottom trawls. Catcher-processors participating in this fishery are between 98 and 200 feet LOA, with from 900 to 3,500 hp. Typically six catcher-processors are involved in this fishery. The gear used includes many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 120 to 190 feet. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 4.5- to 5-inch stretched mesh, hung either square or diamond. Codends have sacrificial chafing gear (usually polyethylene fiber) attached to the bottom and sides to protect them from damage on the stern ramp. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 5.5 to 9 sq. m with a typical horizontal length of 9 to 12 feet and typical angle of attack is 30 to 36º. High aspect doors have a typical horizontal length of 4 to 8 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less the horizontal length of the door. Door spread is typically 60 to 100 fathom sweeps at 11 to 13º. Contact with the seafloor is primarily from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Trawls may be fitted with sonar systems designed to monitor net performance remotely. These third wire systems may improve catching efficiency and help vessel operators avoid net damage.

A bottom trawl with a headrope length of 90 feet and a footrope length of 120 feet weighs approximately 1,800 pounds. Additional gear adds to the weight. A 14-inch rockhopper disc weighs approximately 2,800 pounds (750 pounds of steel components and 2,100 pounds of rubber components) and the headrope floats weigh 700 to 800 pounds. Hydrodynamic effects contribute to reduced downward force.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a distance of approximately three times the depth, and the winches are tightened. The duration of a tow in this fishery is about 3 hours, at a speed of 2.5 to 3.5 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid hangs and fixed gear. They may also be pushed by current, or for other reasons. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

A design objective for modern flatfish nets is to fish the net with minimum bottom contact, to reduce gear damage and drag, and to maintain the quality of the catch. Ideally, only the doors, sweeps, and footrope bobbins will touch the bottom, and these will only touch enough to ensure that fish are herded into the trawl. Any increase in bottom contact increases the drag of the system, causing a reduction in towing speed and/or an increase in fuel consumption along with an increased risk of damage to the gear. Additionally, more bottom contact can cause sand to mix with the catch, which increases processing cost and decreases the value of the product.

The fishing seasons are driven by the seasonal halibut PSC apportionments. Typically, the fishery primarily occurs in April and May because of higher catch rates and better prices. The deepwater flatfish fishery has also changed over time due to state water closures to nonpelagic nets, the American Fisheries Act, market conditions, and gradual increases in fishing capability.

3.4.1.1.2.4 GOA Shallow Water Flatfish Trawl Fishery

The shallow water flatfish fishery targets rock sole and flathead sole using bottom trawls (Figure 3.4-2). Catcher vessels participating in this fishery are shore-based catcher vessels from 58 to 125 feet and ranging from 350 to 1,600 hp. Typically fewer than 25 vessels participate in this fishery.

The gear used by catcher vessels includes many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from 90 to 120 feet. Wing-end spread is typically 12 fathoms with a 120-foot footrope. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5- to 6-inch stretched mesh, hung either square or diamond. Codends have sacrificial chafing gear (usually polyethylene fiber) attached to the bottom and sides to protect them from damage from contact with the sea floor and during retrieval up the stern ramp. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 2.5 to 6 sq. m with a typical horizontal length of 6 to 9 feet and a typical angle of attack is 30 to 36º. High aspect doors have a typical horizontal length of 2 to 4 feet and an angle of attack of 30 to 36º. Bottom contact usually is about one half or less of the horizontal length of the door. Sweep lengths are typically 60 to 100 fathoms at 11 to 13º. Contact with the seafloor is primarily from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Catcher-processors also participate in the shallow water flatfish fishery. Vessels participating in this fishery are catcher-processors from 98 to 185 feet LOA, with 900 to 3,200 hp. Typically, five catcher-processors are involved in this fishery. The gear used includes many different types of bottom trawls, most having a headrope to footrope vertical distance rise of 2 to 5 fathoms. Typical footrope length is from approximately 90 to 130 feet. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5.5- to 7-inch stretched mesh, hung either square or diamond. Codends have sacrificial chafing gear (usually polyethylene fiber) attached to the bottom and sides to protect them from damage on the stern ramp. Otter board or doors are used to spread the net and keep it open during towing. Low aspect doors are made of steel and range in size from 4.5 to 6 sq. m with a typical horizontal length of 6 to 9 feet and the typical angle of attack is 30 to 36º. High aspect doors have a typical horizontal length of 3 to 5 feet and angle of attack of 30 to 36º. Bottom contact usually is about one half or less of the horizontal length of the door. Sweep lengths are typically 60 to 100 fathoms at 11 to 13º. Contact with the seafloor is from doors, sweeps, and footropes. Sweeps are made of wire and covered with rubber bobbins and disks ranging from 2.5 to 4 inches in diameter. Footropes are covered with rubber discs and bobbins, which are 8 to 24 inches in diameter. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Trawls may be fitted with sonar systems designed to monitor net performance remotely. These third wire systems may improve catching efficiency and help vessel operators avoid net damage.

A bottom trawl with a headrope length of 90 feet and a footrope length of 120 feet weighs approximately 1,800 pounds. Footrope for same net 14-inch rockhopper disc weighs 2,100 pounds, steel components 750 pounds, rubber components 2,100 pounds, and flotation 700 to 800 pounds headrope floats. Hydrodynamic effects contribute to reduced downward force.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a distance of approximately three times the depth, and the winches are tightened. Tow duration in this fishery is about 3 hours, at a speed of 2 to 3 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks. Catcher vessels sort catch on deck.

A design objective for modern flatfish nets is to fish the net with minimum bottom contact, to reduce gear damage and drag, and to maintain the quality of the catch. Ideally, only the doors, sweeps, and footrope bobbins will touch the bottom, and these will only touch enough to ensure that fish are herded into the trawl. Any increase in bottom contact increases the drag of the system, causing a reduction in towing speed and/or an increase in fuel consumption along with an increased risk of damage to the gear. Additionally, more bottom contact can cause sand to mix with the catch, which increases processing cost and decreases the value of the product.

The fishing seasons are driven by the seasonal halibut PSC apportionments. There are approximately 7 months of fishing occurring between January and November. The shallow water flatfish fishery has also changed over time due to state water closures to nonpelagic nets, the American Fisheries Act, market conditions, and gradual increases in fishing capability.

3.4.1.1.2.5 GOA Slope Rockfish Trawl Fishery

The slope rockfish fishery is prosecuted by both bottom (Figure 3.4-2) and pelagic trawls (Figure 3.4-1), targeting Pacific ocean perch, northern rockfish, and other pelagic rockfish. Vessels participating in this fishery are shore-based catcher vessels from 70 to 125 feet and ranging from 600 to 1,600 hp. Typically fewer than 30 vessels participate in this fishery. The pelagic trawls used for rockfish are generally used to target Pacific ocean perch. Mid-water configuration is similar to pelagic pollock net, only smaller.

Bottom trawls used in this fishery are rigged to fish over generally rougher substrates. The gear used is a four seam otter trawl and a headrope to footrope vertical distance rise of about 4 to 6 fathoms (24 to 36 feet). Nets are made of polyethylene. Net mesh is 8-inch diamond in the wings and forward belly and 5.5-inch diamond in the intermediate and codend. Double meshes may be used in the codend, and the codend is equipped with chafing gear. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 3.5 to 6 sq. m. Door spread is a function of sweep lengths and angle of attack. Contact with the seafloor is predominantly from doors, bridles, and bobbins. Rockfish nets are designed to stay off the bottom as much as possible by employing numerous floats to buoy the net body and codend. Bridles are made of steel cable and are generally 90 feet long on each side. Footropes are designed to keep the net off the bottom and may utilize tire gear, large disk tires (24-inch-diameter airplane tires), 14- to 18-inch discs or bobbins, or a combination of these. Footropes typically extend from 90 to 120 feet. Steel cable and chain used for the footrope runs through bobbins or discs spaced at intervals of 24 inches or tires grouped together at the bosum, which is the center 10 to 20 feet. Flotation on the net headrope and riblines provides lift to reduce unnecessary drag and increase towing efficiency and performance.

Catcher-processors also participate in this fishery using both bottom and pelagic trawls. Vessels participating in this fishery are catcher-processors from 125 to 295 feet in length and ranging from 1,200 to 6,000 hp. Typically 10 vessels participate in this fishery. The gear used is a four seam otter trawl and a headrope to footrope vertical distance rise of about 4 to 10 fathoms. Nets are made of poly or spectra. Net mesh is 8-inch diamond in the wings and forward belly and 5.5-inch diamond in the intermediate and codend. Double meshes may be used in the codend, and the codend is equipped with chafing gear. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 6.5 to 12 sq. m. Angle of attack ranges from 30 to 36º. Doors typically employ 4-inch-wide door shoes. Door spread in most fishing depths and trawl warp/scope combinations is typically 40 to 45 m. Contact with the seafloor is predominantly from doors, bridles, footropes, and, to a lesser extent, from the codend. Rockfish nets are designed to stay off the bottom as much as possible by employing numerous poly floats to buoy the net body and codend. Bridles are made of steel cable and are generally 90 to 180 feet long on each side. Footropes are designed to keep the net off the bottom by utilizing tire gear, large disk tires (24-inch-diameter airplane tires), or 21-inch discs. Footropes typically extend 100 to 200 feet. Steel cable and chain used for the footrope runs through 18- to 21-inch diameter bobbins and disks spaced intervals of 6 inches. Flotation on the net headrope provides lift to the footrope to reduce unnecessary drag and increase towing efficiency and performance.

Trawls may be fitted with sonar systems designed to monitor net performance remotely. These third wire systems may improve catching efficiency and help vessel operators avoid net damage.

A bottom trawl with a headrope length of 90 feet and a footrope length of 120 feet weighs approximately 1,800 pounds. Footrope for same net 14-inch rockhopper disc weighs 2,100 pounds, steel components 750 pounds, rubber components 2,100 pounds, and flotation 700 to 800 pounds headrope floats. Hydrodynamic effects contribute to reduced downward force.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a minimum distance necessary to achieve the fishing depth. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows are adjusted to curve around depth contours, or avoid location of hangs and fixed gear. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks. The tows in the rockfish fishery have more intermittent bottom contact compared to the other bottom trawl fisheries due to the nature of substrate and fish behaviors.

Because rockfish are fished over rough bottom adjacent to areas with large potential for hangs in some areas, the net is usually fished with very short scope (the ratio of warp to towing depth) to minimize actual contact with the substrate and to allow the net to be quickly lifted if a hangup is sighted. The combination of short trawl warp and the large amount of flotation applied to the headropes and rib lines increases the likelihood that the net will bounce off a rock or hang that may be encountered. This avoids damage to the net. Flotation on the net body reduces potential for ripping or abrading the net on volcanic sand or rock surfaces.

The rockfish season opens in early July and ends by the first week of August. Pacific ocean perch is usually a 2-week fishery and is followed by the northern and pelagic shelf rockfish fisheries which end by late July. The rockfish are caught along the narrow slope area of the shelf break. The rockfish fishery has also changed over time due to the trawl closure in Southeast Alaska, the American Fisheries Act, market conditions, gradual increases in fishing capability, and increased effort since 1996.

3.4.1.1.2.6 GOA Sablefish Longline Fishery

Description of gear used: This fishery is prosecuted with stationary lines (Figure 3.4-3), onto which baited hooks are attached by gangions. Vessels participating in this fishery include small (less than 60-foot) and medium (60- to 90-foot) catcher vessels and catcher-processors (a.k.a. freezer-longliners) of small (less than 60-foot), medium (60- to 90-foot) and a few large (more than 125-foot) vessels. Gear components that contact the bottom include the anchors, groundline, gangions, and hooks. For catcher vessels, anchors are two-prong standard anchors weighing 50 pounds, and groundlines are generally constructed of 3/8-inch sinking line, 10- to 18-inch-long gangions of #72 to #86 twine, and 13/0 to 14/0 circle hooks. Catcher vessels generally use stuck gear (not snap on) with gangions spaced at approximately 3- to 4-foot intervals. On catcher vessels, an average set consists of 15 to 30 skates of groundline, with each skate 100 to 150 fathoms long, for an average length of about 3 nm. Squid is the preferred bait. The ends of each set are anchored and marked with buoys. Intermediate weights are used to minimize the movement of the groundline across the bottom. The lower shot(s) (33 fathoms each) of the anchor line is (are) made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line are plastic buoys and flag poles.

Longline vessels may deploy seabird bycatch avoidance mechanisms, including streamers or paired streamers or other devices. This equipment is deployed along with the longline equipment to frighten seabirds away from gear.

Description of fishery operations: The first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The sets are generally made in a straight line, with some deviation to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. The second anchor is deployed, and the line is left to fish for 6 to 24 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are stripped off the hooks.

Since 1995, the fishery occurs over an 8-month season, opening March 15th (March 1 in 2003) and closing November 15th.

3.4.1.1.2.7 GOA Southeast Demersal Shelf Rockfish Longline Fishery

Description of gear used: Fewer than 20 vessels participate in this fishery. This fishery is prosecuted with stationary lines (Figure 3.4-3), onto which baited hooks are attached by gangions. The dominant species in this fishery is yelloweye rockfish (90 percent), with lesser catches of quillback rockfish and several other rockfish species. Vessels participating in this fishery include few small to medium (less than 75 feet) catcher vessels. Gear components that contact the bottom include the anchors, groundline, gangions, and hooks. For catcher vessels, anchors are two prong standard anchors weighing 30 to 50 pounds, groundlines are generally constructed of 3/8-inch sinking line, 18-inch-long gangions of #72 twine, and 10/0 to 13/0 circle hooks. Many of the catcher vessels use snap-on gear with gangions spaced at 3- to 4-foot intervals. On catcher vessels, an average set consists of 10 skates of groundline, with each skate 100 to 150 fathoms long, for a total length of 1 nm. Both herring and squid are used for bait. The ends of each set are anchored and marked with buoys. The lower shot(s) (33 fathoms each) of the anchor line is (are) made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line are plastic buoys (floats) to mark the gear.

Longline vessels may deploy seabird bycatch avoidance mechanisms, including streamers, paired streamers, or other devices. This equipment is deployed along with the longline equipment to frighten seabirds away from gear.

Description of fishery operations: The first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The set is generally made in a straight line with some deviation to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. Intermediate weights are used to minimize the movement of the groundline across the bottom. The second anchor is deployed, and the line is left to fish for 2 to 12 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are stripped off the hooks.

The fishery opens November 15th and generally lasts 1 to 2 weeks, then reopens January 1st, again lasting 1 to 2 weeks.

3.4.1.1.2.8 GOA Pacific Cod Longline Fishery

Description of Gear Used: This fishery is prosecuted by numerous catcher vessels (ranging from 30 to 60 feet in length) and fewer than 10 freezer longliners (catcher-processors) from 58 to 125 feet long using stationary lines (Figure 3.4-3). Freezer longliners use 9-mm groundline employed with 10- to 14-inch gangions spaced 3 1 /2 feet apart, and No. 6 to 14 modified "J" or full circle hooks. Most vessels use swivel gear and set through autobaiting equipment.

For catcher vessels, the gear is similar to that described above, except that it is generally hand-baited and sets are shorter in length (1 to 3 miles). Sets are weighted to minimize movement of the groundline on the sea floor. Sets are anchored at each end with an anchor weighing 30 to 60 pounds. Many of these vessels use snap-on gear with 5/16-inch groundline. Circle hooks are typically used and are spaced 36 to 42 inches apart. Gear components that contact the bottom include the anchors, groundlines, intermediate weights, gangions, and hooks. Two to four sets are made each day.

Longline vessels may deploy seabird bycatch avoidance mechanisms, including streamers, paired streamers, or other devices. This equipment is deployed along with the longline equipment to frighten seabirds away from gear.

Description of Fishery Operations: Freezer longliner gear is normally set through autobaiting equipment, which adds tension to the groundline. This minimizes the movement of the groundline on the seafloor. Normally a GPS plotter is used to determine the exact trackline of the set, enabling the vessel to retrieve the gear without dragging it across the bottom. It is in the best interest of the fishing operation to do this in order to avoid gear damage. Gear components that contact the bottom include the anchors, groundlines, intermediate weights, gangions, and hooks. Generally the gear is set in a straight line, the average set being 8 miles long. Sets are anchored at both ends with an anchor weighing 60 to 90 pounds. Such a set would deploy 12,320 hooks at a depth of about 30 to 80 fathoms, with an occasional set as deep as 120 fathoms. Often two sets are made, parallel to one another and 1 /2- to 3/4-mile apart. The total time the gear is in the water ranges from 4 to 20 hours. Vessels do not usually set back in the same place, but leapfrog. About four sets are made in a day. Gear is set with an anchor at each end, sometimes with an anchor in the middle of the set. Some vessels use intermediate weights of about 3 to 10 pounds, and most use swivel gear, which adds weight to the line.

For catcher vessels, sets are marked at each end with a flag pole and buoys, which are attached by buoy line to the first anchor. The first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The set is generally made in a straight line with some deviation to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. The second anchor is deployed, and the line is left to fish for 2 to 16 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are stripped or taken off the hooks. The cod fishery may also take halibut as bycatch.

The A season cod longline fishery generally occurs in the western and central GOA, opening on January 1st and lasting until early March. The B season fishery opens September 1 and can be expected to last 6 weeks or less. The fishery is sometimes curtailed by halibut PSC.

3.4.1.1.2.9 GOA Pacific Cod Jig Fishery

Description of gear used: This fishery is prosecuted with actively fished vertical lines (Figure 3.4-4), onto which baited hooks are attached. Vessels participating in this fishery include small (less than 60-foot) catcher vessels. Gear components include an 8-pound jig weight, a 400-pound test monofiliment mainline, and long shank 10/0 J-hooks or 10/0 circle hooks that are looped directly onto the mainline. Vessels employ two to four jig machines (Figure 3.4-5) per vessel. Hooks are dressed with colorful segments of rubber surgical tubing and hoochies and may be baited with strips of herring or other fish.

Description of fishery operations: The vessels look for concentrations of Pacific cod, position vessels to drift over the fish, and may occasionally anchor. The machines drop the jig weight to the bottom and may move the jigs up and down slightly to entice the fish into biting. Each jig machine is adjusted to haul back when there is the right amount of tension on the line (amount of fish). Machines haul up the fish, which are then removed one by one. The vessels move often to stay over fish concentrations. The A season fishery opens January 1st and closes in early March due to the quota being taken. The B season fishery opens September 1 and can be expected to last 6 weeks or less. A state-managed fishery also occurs in state waters.

3.4.1.1.2.10 GOA Pacific Cod Pot Fishery

Description of gear used: The GOA pot cod fishery is prosecuted with square pots (Figure 3.4-6) set on single lines. Vessels used in the inshore fishery are all catcher vessels of small (less than 60-foot LOA) and medium size (60- to 125-foot LOA). The offshore fishery includes some catcher-processors ranging from 90 to over 125 feet. The A season fishery begins on January 1st and concludes in early March. The

B season fishery opens September 1 and can be expected to last 6 weeks or less. Pots used in a directed cod fishery are modified crab pots, which are constructed with a steel bar frame (1.25-inch-diameter) and covered with tarred nylon mesh netting (3.5-inch stretched mesh). Pot sizes range from 6- to 8-foot-diameter square, with the average vessel using 6- by 6-foot pots. Each pot has two or three tunnel openings on opposite sides, with plastic finger funnels to retain the fish. The tunnel eye cannot be greater than 9 inches in any one dimension. An escape panel of untreated cotton must be sewn into the mesh. The pot is attached with a 6- to 8-foot bridle, generally constructed of 1-inch-diameter poly line. A 30- to 60-foot surge, constructed of heavy duty line, is attached to the bridle. The lower shots (33 fathoms each) of line are made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line is a plastic buoy (bag) with an auxiliary buoy attached on a tether line.

Description of fishery operations: Approximately 100 boats participate in this fishery. Pots are baited with chopped herring placed in hanging bait buckets or sacks in the center of the pot. On most vessels, the pot is tipped into the sea with a pot launcher. The shots of line are thrown overboard, followed by the buoys, and the pot sinks to the bottom. The pot rests directly on the bottom. The pot remains stationary on the bottom (except during extreme weather) until it is retrieved, generally about 12 to 48 hours later. Pots are retrieved as follows: the crewman throws a grappling hook between the buoys to retrieve the line. The line is fed into the hauler, and the pot is brought aboard by a crane or picking boom and placed on the pot launcher. Pacific cod are dumped into totes and bled. The fish are put on ice or into recirculating saltwater (RSW) tanks below decks. The pots are rebaited and reset, or they are stored if they are being moved or it is the end of the trip. The A season fishery opens January 1st and is closed in early March due to the quota being taken. The B season fishery opens September 1 and can be expected to last 6 weeks or less. There is also a state-managed fishery in state waters.

3.4.1.1.3 Geographic Distribution and Intensity of Fishing Effort

Information on GOA groundfish fishing effort distribution is available from observer data. Historic information on the distribution of the groundfish fisheries is available from Fritz et al. (1998). More recent information was examined specifically for this analysis and is provided in this section.

To understand recent distribution and intensity of fishing effort for the groundfish fleet, the observer data were queried from the North Pacific Fishery Groundfish database from 1990 to 2002. These data represent vessels that had on-board observers who sampled catch. Each haul was assigned a target based on the composition of the catch of each haul and the predominant weekly catch. The observer data were separated by region based on these identified targets. The data were brought into a geographic information system (GIS) environment using ArcGIS 8.3 ESRI software (this EIS does not endorse the use of any particular software). The target species represented in longitude and latitude was intersected with a 25 sq. km polygon coverage to clearly represent fishing effort.

The fishery effort was summarized for all years from 1990 to 2002 by the total number of sets. The data are displayed using three natural breaks, which is a methodology used for random distributions. It is based on a Jenk’s optimization. The graphics were produced in a format that could be copied in black and white.

3.4.1.1.3.1 GOA Pollock Trawl Fishery

The pollock pelagic trawl fishery in the GOA takes place at relatively low effort levels (fewer than 20 hauls/25 sq. km summed over the 1990 to 2002 period) all around Kodiak Island in the central GOA and sprinkled throughout the eastern portion of the western GOA (Figure 3.4-6). Concentrations of effort (more than 87 hauls/25 sq. km summed over the 1990 to 2002 period) occur on the southern side of Kodiak off Cape Chiniak.

The bottom trawl fishery for pollock in the GOA takes place at relatively low effort levels in the GOA. Some limited bottom trawl effort (more than 14 hauls/25 sq. km summed over the 1990 to 2002 period) has occurred in Shelikof Strait and on the southern side of Kodiak off Cape Chiniak (Figure 3.4-7).

Pollock are generally ubiquitous throughout their GOA range. Pollock tend to aggregate, and the fishery generally occurs in areas with sand, sandy silt, muddy bottom, and pelagically over hard rocky bottoms at depths of 60 to 500 m. Water depth may be greater than the depth at which the fishery occurs. Pollock may aggregate to spawn, to feed, and to breed, as well as in relation to water temperature.

3.4.1.1.3.2 GOA Pacific Cod Trawl Fishery

The Pacific cod bottom trawl fishery in the GOA takes place at very low effort levels (fewer than 25 hauls/25 sq. km summed over the 1990 to 2002 period) on the east and south side of Kodiak Island in the central GOA and sprinkled throughout the eastern portion of the western GOA (Figure 3.4-8). Concentrations of effort (more than 105 hauls/25 sq. km summed over the 1990 to 2002 period) occur on the southern and eastern sides of Kodiak, as well as to the east of Sanak Island. Pacific cod tend to aggregate in areas with sand, sandy mud, cobble, and gravel, at depths of 100 to 600 feet.

3.4.1.1.3.3 GOA Deepwater Flatfish Trawl Fishery

The deepwater flatfish bottom trawl fishery in the GOA takes place at relatively low effort levels (fewer than 26 hauls/25 sq. km summed over the 1990 to 2002 period) throughout the deeper water areas for the central and western GOA (Figure 3.4-9). Concentrations of effort (more than 168 hauls/25 sq. km summed over the 1990 to 2002 period) occur southwest of Chirikof Island. In the spring, the fish tend to aggregate in areas with sand, sandy silt, cobble, gravel, and muddy bottom at depths of 70 to 300 fathoms.

3.4.1.1.3.4 GOA Shallow Water Flatfish Trawl Fishery

The shallow water flatfish bottom trawl fishery in the GOA takes place only around Kodiak Island, for the most part. Concentration of effort (more than 48 hauls/25 sq. km summed over the 1990 to 2002 period) occur on the east and south side of Kodiak Island in the central GOA (Figure 3.4-10). The fish tend to aggregate in areas with sand, sandy silt, and gravel at depths of 15 to 40 fathoms.

3.4.1.1.3.5 GOA Slope Rockfish Trawl Fishery

The slope rockfish pelagic trawl fishery in the GOA takes place at relatively low effort levels (fewer than 33 hauls/25 sq. km summed over the 1990 to 2002 period) in all locations of the GOA. Some effort has taken place in the eastern central and west Yakutat areas of the GOA (Figure 3.4-11).

The bottom trawl fishery for slope rockfish has taken place at relatively low effort levels all along the slope areas of the GOA. Concentrations of bottom trawl effort (more than 71 hauls/25 sq. km summed over the 1990 to 2002 period) has occurred south of Icy Bay, south of Resurrection Bay, and south of Kodiak Island (Figure 3.4-12).

The Pacific ocean perch fishery occurs over sand, gravel, and mud in 90 to 200 fathoms. The northern and pelagic shelf rockfish fisheries occur over rock, gravel, and hard sand at depths of 40 to 80 fathoms.

3.4.1.1.3.6 GOA Sablefish Longline Fishery

The sablefish and Greenland halibut longline fishery in the GOA takes place at relatively low effort levels (fewer than 12 sets/25 sq. km summed over the 1990 to 2002 period) all along the slope areas of the GOA (Figure 3.4-13). Concentrations of effort (more than 38 sets/25 sq. km summed over the 1990 to 2002 period) are sprinkled along the slope. The sablefish longline fishery occurs over gravel, cobble, and mud bottom at depths of 400 to more than 1,000 m. This fishery is often a mixed halibut/sablefish fishery, with grenadiers and shortraker, rougheye, and thornyhead rockfish also taken.

3.4.1.1.3.7 GOA Southeast Demersal Shelf Rockfish Longline Fishery

The demersal shelf rockfish directed longline fishery occurs in Southeast Alaska over bedrock and rocky bottoms at depths of 75 to more than 200 m (246 to over 656 feet).

3.4.1.1.3.8 GOA Pacific Cod Longline Fishery

The Pacific cod longline fishery in the GOA takes place at very low effort levels (fewer than 7 sets/ 25 sq. km summed over the 1990 to 2002 period) on the east side of Kodiak Island in the central GOA and throughout the western GOA (Figure 3.4-14). Concentrations of effort (more than 33 sets/25 sq. km summed over the 1990 to 2002 period) occur in the western GOA east and west of Sanak Island. The fishery occurs over gravel, cobble, mud, sand, and rocky bottom, in depths of 25 to 140 fathoms (150 to 840 feet).

3.4.1.1.3.9 GOA Cod Jig Fishery

The fishery occurs over gravel, cobble, sand, mud, and rocky bottom. In the spring and summer, the fish are found nearshore in shallow (5 to 40 fathoms) waters, but are deeper (40 to 60 fathoms) in the winter. Jig vessels fish primarily from the ports of Homer and Kodiak. Black and dusky rockfish are common "top-off" target species for this fishery.

3.4.1.1.3.10 GOA Pacific Cod Pot Fishery

The Pacific cod pot fishery in the GOA takes place at very low effort levels (fewer than 13 sets/25 sq. km summed over the 1990 to 2002 period) throughout the central GOA and western GOA, as well as in Cook Inlet and outside Prince William Sound (Figure 3.4-15). Concentrations of effort (more than 42 sets/ 25 sq. km summed over the 1990 to 2002 period) occur in the central GOA east and south of Kodiak Island. The fishery occurs over gravel, cobble, mud, sand, and rocky bottom, in depths of 25 to 140 fathoms (150 to 840 feet). Fish are usually found shallower in the summer and deeper in the winter.

3.4.1.1.4 Existing Socioeconomic Conditions

A considerable body of information characterizing existing socioeconomic conditions for the GOA groundfish fisheries, as well as the BSAI groundfish fisheries, has been compiled for the concurrent Alaska revised draft programmatic groundfish SEIS (NMFS 2003a), which includes an analysis of a broad range of alternatives being considered for these fisheries. Information for this section is adapted from that in-process document. Given the overlap in fleets, processing entities, and communities participating in both the GOA and BSAI groundfish fisheries, this section presents socioeconomic information that is applicable to both the GOA and BSAI groundfish fisheries. More comprehensive information, in the form of detailed regional profiles, as well as profiles of a range of communities engaged in and/or dependent upon the GOA and BSAI groundfish fisheries, may be found in the "Interim

Updates of Sector and Community Profiles," which was posted to the Council website http://www.fakr.noaa.gov/npfmc/ on January 28, 2002, and is being incorporated by reference into the Groundfish SEIS (NMFS 2003a). Additionally, the planning record for this EFH EIS includes similar community profile data found in Socioeconomic and Environmental Existing Conditions: Alaska Groundfish Fisheries and BSAI Crab Fisheries (Downs 2003 unpublished manuscript).

Regions and communities engaged in the Alaska groundfish fishery range from the northern BS, to the western Aleutians, to the southernmost part of Southeast Alaska, along with ports in Washington and Oregon. In order to characterize this engagement, quantitative information is described in relation to six geographic areas: four in Alaska, one in Washington, and one in Oregon. The regions were defined based on logical socioeconomic and geographic units. Internal consistency with respect to type of engagement or dependence upon the groundfish fishery was more important in defining the regions than attempting to make them comparable for non-groundfish-related criteria. The regional definitions are consistent with those used in the concurrent revised draft programmatic groundfish SEIS (NMFS 2003a), as well as the Steller sea lion protection measures analysis (NMFS 2001b) and the detailed sector and community profiles on the Council website. The regions and their constituent jurisdictions or geographies are listed in Table 3.4-1.

Tables 3.4-2 through 3.4-7 present information on participation in the groundfish fishery by region for processing and catcher vessel sectors. Parallel tables for each of the individual regions and time series information on most of these same indicators are available in Downs (2003). Disclosure of actual value information for communities or other areas with fewer than four entities within a given sector (or class) of operations is not possible under existing confidentiality restrictions. The number of entities operating in any given location is not confidential. In order to provide a rough approximation of the economic contribution of the commercial fisheries to communities or other areas where actual values cannot be disclosed, normative values were calculated. In these cases, the total value for a sector (or class) within a region was averaged over the number of participants in the region, and then these normative values were multiplied by the number of entities present in a given area to arrive at totals that were applied to communities or other relevant areas. Because individual operations vary considerably in size, this method will under-represent values in some locations and overstate them in others, but it is the best representation that can be given under existing data disclosure constraints.

Table 3.4-2 presents information on selected groundfish fishery participation measures by region for 2001. As shown, the relative regional contribution of different harvest and processing sectors varies widely by region. For example, the concentration of processing activity in the Alaska Peninsula and AI region is clear, as is the Washington Inland Waters region's dominance over the catcher fleet.

Table 3.4-3 presents information on the volumes of deliveries to inshore processing plants in the different regions, along with associated values. As shown, volumes and values vary widely by region both in terms of totals and in terms of the relative volume or value of the different species or species groups.

Table 3.4-4 presents information on processing value by sector and region of ownership. While processing activity may take place primarily or almost exclusively in Alaska, economic ties to Washington State through ownership are evident.

Table 3.4-5 presents information on the relative importance of catch from different FMP areas for vessels owned by residents of the various regions. Table 3.4-6 displays information on a species basis, while Table 3.4-7 shows information on FMP area distribution by the volume and value of retained pollock and Pacific cod catch for regional fleets.

Tables 3.4-8 through 3.4-11 present data on the distribution of local fleets by community within each of the four Alaska regions. Average per-vessel values must be used to estimate percentage of regional total to preserve confidentiality of individual operations.

In terms of processing plant distribution, for the Aleutians region, the plants are divided into two subsectors: the EBS pollock shoreplants and the Alaska Peninsula/Aleutian inshore plants, based on distinctive operational profiles as described in the sector profiles document on the Council website. The EBS pollock inshore plants include three large onshore processors in Unalaska, one large shore processor in Akutan, one inshore floating processor currently in Beaver Inlet on Unalaska Island, and one inshore floating processor in Akutan Bay. These same plants have operated every year during the 1992 to 2000 period (although one of the floaters moved from Beaver Inlet to Akutan Bay during this time). The Alaska Peninsula/Aleutian inshore plants are all other groundfish plants in the region (Aleutians East Borough and the Aleutians West Census Area) exclusive of the aforementioned six EBS pollock inshore plants (and including the plants in Sand Point and King Cove, among others). The EBS pollock inshore plants dominate processing in the region (and, indeed, the state) in terms of volume of groundfish processed. The number of smaller plants in the region has varied from five to eight per year from 1992 to 2000. In 2000, eight Alaska Peninsula/Aleutian inshore plants (i.e., the regional non-EBS pollock sector plants) reported processing groundfish in Adak (1), Chignik (1), Unalaska/Dutch Harbor (3), King Cove (1), Sand Point (1), and St. Paul (1).

For the Kodiak Island region, the number of shoreplants processing groundfish declined somewhat during this period. Since 1995, one plant has operated at Alitak and the rest of the region's plants have operated in Kodiak.

For the Southcentral region, the volume of groundfish processed varied from year-to-year from 1992 to 2000 and fell sharply from 1998 to 1999 to 2000. The number of shoreplants ranged between 15 and 21 from 1992 to 2000. The reported value of groundfish processed product has been around $30 million annually from 1998 to 2000, following a peak of $40 million in 1997. In 2000, 17 regional plants reported processing groundfish in Anchorage (2), Cordova (3), Homer (5), Kenai (4), Ninilchik (1), and Seward (2).

For the Southeast Alaska region, groundfish volume has fluctuated considerably from year-to-year from 1992 to 2000, and the number of groundfish shoreplants has declined somewhat from a peak in 1994 to 1996. The total value of their groundfish output in 2000 was roughly three-quarters of that seen during the peak years. In 2000, 13 regional plants reporting groundfish processing operated in Hoonah (1), Juneau (2), Ketchikan (2), Petersburg (2), Pelican (1), Sitka (3), and Yakutat (2).

3.4.1.2 BSAI Groundfish Fisheries

3.4.1.2.1 Summary of the BSAI Groundfish FMP

The BSAI Groundfish FMP was implemented on January 1, 1982, and has been amended numerous times. The plan encompasses the EEZ in that portion of the North Pacific Ocean adjacent to the AI which is between 170° W and the United States-Russian Convention Line of 1867, within the EBS. The plan area is divided into two regulatory areas: the EBS and the AI. The plan covers all commercial fisheries for all finfish and marine invertebrates except salmonids, shrimps, scallops, snails, king crab, Tanner crab, Dungeness crab, corals, surf clams, horsehair crab, lyre crab, Pacific halibut, and Pacific herring.

The primary objectives of the plan are to promote conservation while providing for optimum yield, promote efficient use of fishery resources, promote fair resource allocation, and use the best scientific data available in making management decisions. To accomplish these objectives, a large suite of management measures and regulations has been adopted. Management measures include catch limits, permit requirements, prohibited species, marine mammal conservation measures, fishing area restrictions, gear restrictions, reporting requirements, observer program, effort limitation programs, community development quota programs, inseason adjustments, gear allocations, inshore/offshore allocations, retention and utilization requirements, experimental fishing permits, and other measures. Current fishery regulations can be viewed and downloaded from the NMFS Alaska Region website: www.fakr.noaa.gov.

Optimum yield (OY) is the amount of fish that will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities, taking into account the protection of marine ecosystems; is prescribed as such on the basis of maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and, in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery. For the BSAI groundfish fisheries, the OY of the groundfish complex is 1.4 to 2.0 million metric tons (mmt) to the extent that this can be harvested consistently with the management measure specified in the FMP.

Fisheries regulations of the FMP apply to five categories of species or species groups that are likely to be taken in the groundfish fishery. The optimum yield concept is applied to all categories except the prohibited species category. These categories are described as follows:

1. Prohibited species are those species and species groups the catch of which must be returned to the sea with a minimum of injury except when their retention is authorized by other applicable law. Groundfish species and species groups under this FMP for which the quotas have been achieved shall be treated in the same manner as prohibited species. Prohibited species include Pacific halibut, Pacific herring, salmonids, king crab, and Tanner crab.

2. Target species are commercially important and generally targeted upon by the groundfish fishery. Sufficient data exist to specify TACs and to manage each species or species group separately. Catch records must be kept. Target species include pollock, Pacific cod, Atka mackerel, and sablefish, as well as numerous species of rockfish and flatfish.

3. Other species have little current economic value and are not usually targeted upon, but they may be significant components of the ecosystem or have economic potential. A single TAC applies to this category as a whole. Catch records must be kept. Other species include sculpins, sharks, skates, and octopus.

4. Forage Fish species are species which are critical food sources for marine mammals, seabirds, and fish species. Forage fish species include smelts, lantern fish, sandfish, gunnels, krill, etc.

5. Nonspecified species are those species and species groups of no current economic value taken by the groundfish fishery only as an incidental catch in the target fisheries. Non-specified species include numerous fish and invertebrates such as grenadiers, eelpouts, sea urchins, mussels, etc. No record of catch is necessary, and no TAC is established for this category.

A brief overview of management measures is provided below.

Catch limits: Catch limits (TACs) are established for target and other species or species groups. The sum of TACs for all target species must be less than or equal to the maximum OY established for the groundfish complex (2.0 mmt).

Permit requirements: All vessels fishing in the federal EBS or AI management area, or receiving fish from this area, must have a current fishing permit.

Prohibited species: Regulations have been implemented to control the incidental bycatch and injury of prohibited species (salmon, halibut, red king crab, Tanner crab, snow crab, and herring). Regulatory measures have included trawl closure areas, bycatch limits, gear regulations, and careful release requirements. An incentive program to reduce bycatch rates of prohibited species is authorized under the FMP.

Marine mammal and seabird conservation measures: To protect walrus, fishing vessels are prohibited within 12 miles of Round Island, the Twins, and Cape Peirce in northern Bristol Bay from April 1 through September 30. Steller sea lion protection measures imposed in fisheries for pollock, Atka mackerel, and Pacific cod include restrictions on fishing activity in critical habitat (including restricted activity zones around rookeries and haulouts) and measures designed to disperse fishing activity in time and space over the year. The dispersion measures are meant to decrease the chance of localized depletion of prey for Steller sea lions. Hook-and-line groundfish and halibut fishermen are required to use gear devices and fishing methods to reduce bycatch of seabirds. There is also a prohibition on commercial exploitation of forage fish species such as capelin, sand lance, and smelt, which are eaten by various marine mammals and seabirds.

Fishing area restrictions: Area restrictions have been implemented to control bycatch of prohibited species and to protect sensitive benthic habitat from potential impacts due to fishing. Areas may be off-limit to certain gear types or all gear types. Some area restrictions are seasonal, whereas others have been year-round or closed when a pre-specified level of bycatch is reached.

Gear restrictions: Gear restrictions are made for conservation and management of fishery resources. The FMP authorizes the use of trawls, hook-and-line, pots, jigs, and other gear types as defined in regulations.

Reporting requirements: Recordkeeping and reporting requirements have been implemented to keep track of fishing effort, landings, processing, and transfers. Processors are required to file an annual notice of intent to operate with ADF&G and must complete and submit fish tickets documenting purchases from catcher vessels. Operators of catcher vessels who sell fish at dockside must also file fish tickets as catcher-sellers. Catcher-processor and mothership-processor vessel operators are required to have a federal permit, must complete a NMFS WPR, and may also voluntarily submit fish tickets. Shoreside processors must also file a WPR, or participate in an electronic reporting system. In addition, all processors are now required to complete an ADF&G Commercial Operators Annual Report. There are numerous other requirements for recordkeeping and reporting to ensure timely and effective in-season management of bycatch and individual groundfish stocks.

Observer program: A domestic observer program was implemented beginning with the 1990 fishing year. Observers collect biological and catch and discard information. All vessels capable of hosting an observer may be required to do so at the host vessel's expense. As currently implemented, vessels over 125 LOA are required to have an observer on-board at all times when groundfishing, vessels of 60 to 124 feet LOA are required to have observers on-board 30 percent of the time while participating in a fishery, and vessels under 60 feet LOA are generally exempt from the requirements for observer coverage.

Effort limitation programs: In 1995, a moratorium on entry of new vessels into the groundfish fishery was implemented. The increasingly large number of vessels fishing for a limited resource had created a race for fish, characterized by short seasons and economic inefficiency. Although a moratorium did not resolve the underlying problems of existing overcapitalization and excess effort in the groundfish fisheries, the intent of the moratorium was to prevent these problems from worsening while comprehensive solutions are being developed. The eligibility period for moratorium qualification was January 1, 1988, through February 9, 1992, during which time a vessel must have made at least one legal landing of groundfish. In June 1995, the Council adopted a license limitation program as Amendment 39 to supersede the vessel moratorium. The license limitation program was implemented in 2000. Beginning in 1995, an IFQ program was implemented to manage the fixed gear halibut and sablefish fisheries.

Community development quota programs: Ten percent of the BSAI pollock TAC is allocated to qualifying community development projects in western Alaska (CDQ fisheries), as is 20 percent of the fixed gear allocation of sablefish. For most other groundfish species (except squid), 7.5 percent of the TAC is allocated to CDQ fisheries.

Seasonal allocations and inseason adjustments. Harvest allocations and management are based on the calendar year. Fishing seasons for specific species or gear types may be set by regulatory amendment and may differ from the fishing year. For example, fixed gear sablefish fisheries begin on March 1 in 2003. All trawl fisheries are delayed until January 20. Trawl fisheries also open and close based on seasonal allocation of halibut and crab bycatch limits. Hook and line gear for Pacific cod can close because of halibut bycatch limits.

Gear allocations: Some TACs have been allocated to vessels using particular gear types. Sablefish in the EBS is allocated 50 percent to fixed gear and 50 percent to trawl gear; in the AI, sablefish is allocated 75 percent to fixed gear and 25 percent to trawl gear. Pacific cod in the BSAI is allocated 51 percent to fixed gear and 47 percent to trawl gear, and 2 percent to jig gear. Amendment 64, adopted by the Council in October 1999, further allocated the fixed gear apportionment.

Inshore/offshore allocation: The pollock TAC in the BSAI was allocated between inshore and offshore components beginning in 1992.

Retention and utilization requirements: The practice of roe-stripping of pollock (defined as the taking of roe from female pollock and the subsequent discard of the carcasses of females and all male pollock) has been prohibited. Full retention of all pollock and Pacific cod caught in all BSAI fisheries was required beginning on January 1, 1998.

Experimental fishing permits: The FMP authorizes the NMFS Regional Administrator to issue experimental fishing permits for limited experimental purposes that allow the harvest of groundfish that would otherwise be prohibited. Experimental fishing permits might be issued for fishing in areas closed to fishing, continued fishing with gear otherwise prohibited, or continued fishing for species for which the quota has been reached.

Habitat protection measures: The FMP authorizes the establishment of regulations to manage fishing or fishing vessels for habitat reasons. Reasons include 1) protecting habitat by establishing gear, timing, or area restrictions; 2) preventing the commercial harvest of important forage fish; 3) preventing the harvest of fish in contaminated areas; and 4) restricting the disposal of fishing gear.

3.4.1.2.2 Description of the Fisheries and Gears

3.4.1.2.2.1 Bering Sea Pollock Trawl Fishery

Description of gear used: This fishery is prosecuted with pelagic otter trawls (Figure 3.4-1) rigged to fish for schooled or scattered pollock. Vessels participating in this fishery include about 112 catcher vessels and 16 catcher-processor vessels. Typical vessel length for catcher vessels is about 120 feet (range is 70 to 190 feet) LOA, and about 220 to 350 feet LOA for catcher-processors. The gear used has meshes in the front end as large as 32 to 64 m (105 to 210 feet) and typically has a headrope to footrope vertical distance rise of 10 to 30 fathoms (60 to 180 feet). To achieve these large openings with a minimum of drag, the mesh sizes are very large, and twine size is relatively small. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 4- to 4.5-inch stretched mesh. Otter boards or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 5 to 14 sq. m. In the pelagic fishery the doors do not come in contact with the ocean floor. Door spread in most fishing depths ranges from 100 to 180 m (328 to 590 feet), and trawl warp/scope to depth ratio is typically 3 to 1. Contact with the seafloor, when it occurs, is from weight clumps and footrope. Long wire rope bridles attach the net to the doors (the doors are not on the bottom). Unlike other groundfish trawl fisheries, there are no discs attached to the footropes on these trawls. Footropes typically extend 180 to 450 m (590 to 1,475 feet).

Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp. Everything from the footrope aft, including the codend, is neutrally buoyant.

Description of fishery operations: Sets are made on schooled or scattered pollock as indicated by electronics. When set, the codend, net, and sweeps are unwound from a net reel, then the doors are attached. Wire cable attached to each door is let out to a distance approximately three times the depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. Tow duration in this fishery ranges from 20 minutes to 10 hours (depending upon catch rates), at a speed of 3.5 to 4.5 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. Quite often, vessels will turn around (180º) while towing, making several passes over the same general area. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

3.4.1.2.2.2 Aleutian Islands and Bogoslof Pollock Trawl Fishery

Although the Bogoslof area is closed, if that fishery were to occur, it would have fleet characteristics of the EBS, but habitat and fishery characteristics of the AI.

Description of gear used: This fishery is prosecuted with otter trawls rigged to fish for schooled and scattered pollock. Vessels that have participated in this fishery included about 30 catcher vessels and about 10 catcher-processor vessels. Typical vessel length for catcher vessels is about 140 feet LOA, and about 220 to 350 feet LOA for catcher-processors. The gear used is very large mesh mid-water trawls (Figure 3.4-1), typically having a headrope to footrope vertical distance rise of 10 to 30 fathoms. To achieve these large openings with a minimum of drag, the mesh sizes are very large and the twine size relatively small. Front meshes of a large mid-water net may be as large as 32 to 64 m (105 to 210 feet). Net mesh gets smaller towards the intermediate and codend, with the codend typically having 4- to 4.5-inch stretched mesh. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 7 to 14 sq. m. Door spread in most fishing depths ranges from 100 to 180 m (328 to 590 feet) with a trawl warp/scope ratio of 3 to 1. There is no intentional seafloor contact because of the rough bottom conditions, which would result in torn or lost mid-water trawls. Long wire rope bridles attach the net to the doors. Unlike other groundfish trawl fisheries, there are no discs attached to the footropes on these trawls. Footropes typically extend 180 to 450 m (590 to 1,475 feet).

Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp. Everything from the footrope aft, including the codend, is neutrally buoyant.

Seasons were historically short, low quota, and low effort compared to the EBS fishery. The quota is taken in one season, from January to the end of March.

Description of fishery operations: Sets are made on schooled or scattered pollock as indicated by electronics. When set, the codend, net, and sweeps are unwound from a net reel, then the doors are attached. Wire cable attached to each door is let out to a distance of approximately three times the depth. Modern trawl winches are designed to adjust tension automatically and release when necessary. Tow duration in this fishery is about 3 hours (depending upon catch rates) at a speed of 3.5 to 4.5 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. Quite often, vessels will turn around (180º) while towing, making several passes over the same general area. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

3.4.1.2.2.3 BSAI Pacific Cod Trawl Fishery

Description of gear used: This fishery is prosecuted with bottom trawls (Figure 3.4-2). Vessels participating in this fishery include approximately 84 catcher vessels and 27 catcher-processor vessels. Typical vessel length for catcher vessels is from 60 to 180 feet LOA and about 107 to 295 feet LOA for catcher-processors. The gear used includes many different types of bottom trawls, most typically having a headrope to footrope vertical distance rise of 1 to 5 fathoms (6 to 30 feet). Net mesh gets smaller towards the intermediate and codend, with the codend typically having 5 1 /2- to 8-inch stretched diamond mesh. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 4 to 10 sq. m. Door spread in most fishing depths is typically 100 m (328 feet), and the trawl warp/scope to depth ratio is typically 4 to 1. The mouth of the net is a horizontal opening of about 15 m (49 feet). Contact with the seafloor is primarily from doors, sweeps, and bobbins. The vertical opening is achieved by floats attached to the headrope. Floats may be spaced intermittently along the riblines to achieve neutral buoyancy. Modern doors (starting in the mid-1980s) are designed to spread with minimal bottom contact. Vented, cambered, foam-filled doors are examples of more modern doors.

Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp and contact with the seafloor.

Sweeps are made of wire and covered with rubber disks ranging from 4 to 8 inches in diameter. Footropes, constructed of chain or steel cable, typically extend 100 to 200 feet and are covered with rubber discs and bobbins, which are 8 to 18 inches in diameter and are designed to roll. The larger diameter bobbins are spaced at intervals of 12 to 48 inches.

Description of fishery operations: When set, the codend, net, and sweeps are unwound from a net reel, and the doors are attached. Wire cable attached to each door is let out to a distance approximately four times the depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. Tow duration in this fishery is 2 to 4 hours (depending upon catch rates) at a speed of 3 to 4 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. Quite often, vessels will turn around (180º) while towing, making several passes over the same general area. At haulback, the setting procedure is reversed.

3.4.1.2.2.4 Bering Sea Rock Sole Trawl Fishery

Description of gear used: This is a bottom trawl fishery using an otter trawl (Figure 3.4-2) rigged to fish effectively for flatfish which generally live on or very near the substrate. All vessels currently involved with this fishery in the EBS are trawl catcher-processors (CPs). Typical vessel length (LOA) for boats targeting rock sole is from 107 to 295 feet LOA for catcher-processors. Approximately 20 vessels participate in the rock sole directed fishery.

Rock sole is fished with a two- or four-seam trawl with a relatively low vertical opening (typically 1 to 3 fathoms). Nets are made of polyethylene netting, with codends and intermediates using 5.5- to 8-inch mesh in square or diamond configuration. Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp and occasional contact with the seafloor.

Steel trawl doors ranging in size from 5 to 11 sq. m spread the nets horizontally. Door spread varies with fishing depth and rigging style, but generally ranges from 100 to 200 m (328 to 656 feet). The rigging between the net and the doors includes bridles and sweeps (mudgear), ranging in length from 30 to 200 m (98 to 656 feet), which herd fish into the path of the trawl. Sweeps are made of steel cable covered by rubber disks ranging from 4 to 8 inches in diameter. Footropes keep the front of the net off the bottom to protect it from damage. They are made of rubber disks and bobbins 12 to 18 inches in diameter strung on chain or wire at 18- to 48-inch intervals. Bobbins are mostly rubber, but sometimes are hollow steel balls designed to roll along the seabed.

Contact with the seafloor is predominantly from doors, sweeps, and bobbins. A design objective for modern flatfish nets is to fish the net with minimum bottom contact to reduce gear damage and drag and to maintain the quality of the catch. Ideally, only the doors, sweeps, and footrope bobbins will touch the bottom, and these will only touch enough to ensure that fish are herded into the trawl. Any increase in bottom contact increases the drag of the system, causing a reduction in towing speed and/or an increase in fuel consumption along with an increased risk of damage to the gear. Additionally, more bottom contact can cause sand to mix with the catch, which increases processing cost and decreases the value of the product.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a distance approximately three times the depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

3.4.1.2.2.5 Bering Sea Yellowfin Sole Trawl Fishery

Description of gear used: This fishery is prosecuted with otter trawls (Figure 3.4-2) rigged to fish effectively for flatfish, which live on or very near the substrate. Approximately 20 to 30 trawl catcher-processor vessels are currently involved with this fishery in the EBS. Typical vessel length (LOA) for boats targeting yellowfin sole is from 107 to 341 feet. Yellowfin sole is fished with a two- or four-seam trawl with a relatively low vertical opening (typically 1 to 3 fathoms). Nets are made of polyethylene netting, with codends and intermediates using 5.5- to 8-inch mesh in square or diamond configuration. Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp and occasional contact with the seafloor.

Otter boards or doors are used to spread the net and keep it open during towing. Steel trawl doors ranging in size from 5 to 11 sq. m spread the nets horizontally. Door spread varies with fishing depth and rigging style, but generally ranges from 100 to 200 m (328 to 656 feet). The rigging between the net and the doors includes bridles and sweeps (‘mudgear’), ranging in length from 30 to 200 m (98 to 656 feet), which herd fish into the path of the trawl. Sweeps are made of steel cable covered by rubber disks ranging from 4 to 8 inches in diameter. Footropes keep the front of the net off the bottom to protect it from damage. They are made of rubber disks and bobbins 12 to 18 inches in diameter strung on chain or wire at 18- to 48-inch intervals. Bobbins are mostly rubber, but sometimes are hollow steel balls designed to roll along the seabed.

Contact with the seafloor is predominantly from doors, sweeps, footropes, and to a lesser extent from the codend. Although codends are usually rigged with some poly twine chafing gear, a design objective for modern flatfish nets is to employ sufficient poly floats to buoy the net body and codend to keep it mostly off the bottom or at least reduce the drag on the bottom to the greatest extent possible. This reduces the problem of sand and mud in the catch (which lowers product value and complicates processing). Sweeps are made of steel cable covered by rubber bobbins and disks ranging from 4 to 8 inches in diameter. Sweep sections (both sides) range in length from 250 to 800 feet and occasionally longer for nets with smaller footrope extensions and larger sweeps extensions. Footropes are designed to keep the net off the bottom by utilizing rubber disks and bobbins that range in size from 8 to 16 inches in diameter. Steel cable and chain used for the footrope runs through rubber disks at spaced intervals of 18 to 48 inches. Flotation on the net headrope provides lift to the footrope to reduce unnecessary drag and increase towing efficiency and performance. Some headrope/footrope combinations are designed to be as much as 70 percent buoyant at depth. Footropes typically extend 100 to 200 feet.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a distance of approximately 3 times the depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

3.4.1.2.2.6 Bering Sea Flathead Sole/Other Flatfish Trawl Fishery

Description of gear used: This is a bottom trawl fishery using an otter trawl (Figure 3.4-2) rigged to fish effectively for flatfish which generally live on or very near the substrate. All vessels currently involved with this fishery in the EBS are trawl CPs. Typical vessel LOA for boats targeting flathead sole and other flatfish is from 107 to 295 feet for catcher-processors. Approximately 20 to 30 vessels participate in the flathead sole directed fishery, as well as other flatfish fisheries.

Flathead sole is fished with a two- or four-seam trawl with a relatively low vertical opening (typically 1 to 3 fathoms). Nets are made of polyethylene netting, with codends and intermediates using 5.5- to 8-inch mesh in square or diamond configuration. Trawl codends are usually made with polyethylene netting attached to four longitudinal riblines. The riblines are typically chain, wire, or synthetic rope. Floats are attached along the length of the codend to counteract the weight of the steel components. Container lines around the circumference are attached along the length of the codend to restrict the expansion of the netting, preventing damage and allowing the codend to be hauled up a stern ramp. Sacrificial chafing gear, typically polyethylene fiber, is attached to the codend to protect it from abrasion on the stern ramp and occasional contact with the seafloor.

Steel trawl doors ranging in size from 5 to 11 sq. m spread the nets horizontally. Door spread varies with fishing depth and rigging style, but generally ranges from 100 to 200 m (328 to 656 feet). The rigging between the net and the doors includes bridles and sweeps (mudgear), ranging in length from 30 to 200 m (98 to 656 feet), which herd fish into the path of the trawl. Sweeps are made of steel cable covered by rubber disks ranging from 4 to 8 inches in diameter. Footropes keep the front of the net off the bottom to protect it from damage. They are made of rubber disks and bobbins 12 to 18 inches in diameter strung on chain or wire at 18- to 48-inch intervals. Bobbins are mostly rubber, but sometimes are hollow steel balls designed to roll along the seabed.

Contact with the seafloor is predominantly from doors, sweeps, and bobbins. A design objective for modern flatfish nets is to fish the net with minimum bottom contact to reduce gear damage and drag and to maintain the quality of the catch. Ideally, only the doors, sweeps, and footrope bobbins will touch the bottom, and these will only touch enough to ensure that fish are herded into the trawl. Any increase in bottom contact increases the drag of the system, causing a reduction in towing speed and/or an increase in fuel consumption along with an increased risk of damage to the gear. Additionally, more bottom contact can cause sand to mix with the catch, which increases processing cost and decreases the value of the product.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a distance of approximately 3 times the depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. They may also be pushed by current, or for other reasons. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

3.4.1.2.2.7 Aleutian Islands Pacific Ocean Perch and Northern Rockfish Trawl Fishery

Description of gear used: This fishery is prosecuted with otter trawls (Figure 3.4-2) rigged to fish over generally rougher substrates. Target species in the BSAI fishery include Pacific ocean perch, shortraker rockfish, and rougheye rockfish. All vessels currently involved with this fishery are trawl CPs. Typical vessel LOA for boats targeting rockfish is from 107 to 295 feet. The gear used is a four-seam otter trawl and a headrope to footrope vertical distance rise of about 4 to 6 fathoms. Nets are made of polyethylene. Net mesh is 8-inch diamond in the wings and forward belly and 5.5-inch diamond in the intermediate and codend. Double meshes may be used in the codend, and the codend is equipped with chafing gear. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 6.5 to 12 sq. m. The door spread in most fishing depths and trawl warp/scope combinations is typically 45 to 50 m (148 to 164 feet). Contact with the seafloor is predominantly from doors, bridles, and bobbins. Rockfish nets are designed to stay off the bottom as much as possible by employing numerous floats to buoy the net body and codend. Bridles are made of steel cable and are generally 90 feet long on each side. Footropes are designed to keep the net off the bottom and may utilize tire gear, large disk tires (24-inch-diameter airplane tires), 21-inch discs or bobbins, or a combination of these. Footropes typically extend 100 to 200 feet, plus an additional 40-foot extension from net wing ends on both sides. Steel cable and chain used for the footrope runs through bobbins or discs spaced at intervals of 24 inches or tires grouped together at the bosum, which is the center 30 to 80 feet. Flotation on the net headrope and riblines provides lift to reduce unnecessary drag and increase towing efficiency and performance.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a minimum distance necessary to achieve the fishing depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows are adjusted to curve around depth contours, or avoid location of hangs and fixed gear. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

Because rockfish are fished over rough bottom adjacent to areas with large potential for hangs in some areas, the net is usually fished with very short scope (the ratio of warp to towing depth) to minimize actual contact with the substrate and allow the net to be lifted quickly if a hangup is sighted. The combination of short trawl warp and the large amount of flotation applied to the headropes and riblines increases the likelihood that the net will bounce off a rock or hang that may be encountered. This avoids damage to the net. Flotation on the net body reduces potential for ripping or abrading the net on volcanic sand or rock surfaces. The tows in the rockfish fishery have more intermittent bottom contact compared to the other bottom trawl fisheries due to the nature of substrate and fish behaviors.

3.4.1.2.2.8 Aleutian Islands Atka Mackerel Trawl Fishery

Description of gear used: This fishery is prosecuted with otter trawls (Figure 3.4-2) rigged to fish over generally rougher substrates. All vessels currently involved with this fishery are trawl CPs (approximately 8 to 12 vessels). Typical vessel length (LOA) for boats targeting Atka mackerel is from 107 to 295 feet. The gear used is a four-seam otter trawl and a headrope to footrope vertical distance rise of about 1 to 4 fathoms. Nets are made of polyethylene. Net mesh is 8-inch diamond in the wings and forward belly and 5.5-inch diamond in the intermediate and codend. Double meshes may be used in the codend, and the codend is equipped with chafing gear. Otter board or doors are used to spread the net and keep it open during towing. Doors are made of steel and range in size from 6.5 to 12 sq. m. The door spread in most fishing depths and trawl warp/scope combinations is typically 45 to 50 m (148 to 164 feet). Contact with the seafloor is predominantly from doors, bridles, and bobbins. Atka mackerel nets are designed to stay off the bottom as much as possible by employing numerous floats to buoy the net body and codend. Bridles are made of steel cable and are generally 90 feet long on each side. Footropes are designed to keep the net off the bottom and may utilize tire gear, large disk tires (24-inch-diameter airplane tires), 21-inch discs or bobbins, or a combination of these. Footropes typically extend 100 to 200 feet, plus an additional 40-foot extension from net wing ends on both sides. Steel cable and chain used for the footrope runs through bobbins or discs spaced at intervals of 24 inches or tires grouped together at the bosum, which is the center 30 to 80 feet. Flotation on the net headrope and riblines provides lift to reduce unnecessary drag and increase towing efficiency and performance.

Description of fishery operations: When set, the net is unwound from a net reel, the sweeps are attached, and then the doors are attached. Wire cable attached to each door is let out to a minimum distance necessary to achieve the fishing depth. Modern trawl winches are designed to automatically adjust tension and release when necessary. The tow duration in this fishery is about 1 to 4 hours, at a speed of 3 to 4 knots. Tows are adjusted to curve around depth contours, or avoid location of hangs and fixed gear. At haulback, the setting procedure is reversed, and the codend is dumped into the fish-hold below decks.

Because mackerel are fished over rough bottom adjacent to areas with large potential for hangs in some areas, the net is usually fished with very short scope (the ratio of warp to towing depth) to minimize actual contact with the substrate and to allow the net to be lifted quickly if a hangup is sighted. The combination of short trawl warp and the large amount of flotation applied to the headropes and riblines increases the likelihood that the net will bounce off a rock or hang that may be encountered. This avoids damage to the net. Flotation on the net body reduces the potential for ripping or abrading the net on volcanic sand or rock surfaces. The tows in the Atka mackerel fishery have more intermittent bottom contact compared to the other bottom trawl fisheries due to the nature of substrate and fish behaviors.

3.4.1.2.2.9 BSAI Pacific Cod Longline Fishery

Description of gear used: This fishery is prosecuted with stationary lines (Figure 3.4-3), onto which baited hooks are attached by gangions. Vessels participating in this fishery include small to medium (less than 75-foot) catcher vessels and catcher-processors (a.k.a. freezer-longliners) that range from 90 to 200 feet in length. About 5 to 10 catcher vessels and 35 catcher-processors participate in the directed cod fishery. Gear components that contact the bottom include the anchors, groundline, gangions, and hooks.

For catcher vessels, anchors are two-prong standard anchors weighing 50 pounds, groundlines are generally constructed of 3/8-inch sinking line, 16- to 18-inch-long gangions of #72 twine, and 12/0 circle hooks. Many of the catcher vessels use snap-on gear with gangions spaced at approximately 3- to 4-foot intervals. On catcher vessels, an average set consists of 12 skates of groundline, with each skate 300 fathoms long, for a total length of 3.5 nm. Squid is the preferred bait. The ends of each set are anchored and marked with buoys. The lower shot(s) (33 fathoms each) of the anchor line is (are) made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line are plastic buoys.

Catcher-processors use slightly different gear: 9-mm groundline is employed with 10- to 14-inch gangions, spaced 3 1 /2 feet apart, and No. 6 to 14 modified "J" or full circle hooks. Most vessels use swivel gear.

Description of fishery operations: For catcher vessels, the first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The set is not made in a straight line; instead the boat will steer to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. The second anchor is deployed, and the line is left to fish for 2 to 24 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are stripped off the hooks.

Freezer longliner gear is normally set through autobaiting equipment, which adds tension to the groundline and, thus, minimizes the movement of the groundline on the seafloor. Normally a GPS plotter is used to determine the exact trackline of the set, enabling the vessel to retrieve the gear without dragging it across the bottom. It is in the best interest of the fishing operation to do this in order to avoid gear damage. Generally the gear is set in a straight line, the average set being 8 miles long. Such a set would deploy 12,320 hooks at a depth of about 30 to 80 fathoms, with an occasional set as deep as 120 fathoms. Often two sets are made, parallel to one another and 1 /2- to 3/4-mile apart. The total time the gear is in the water ranges from 4 to 20 hours. Vessels do not usually set back in the same place, but leapfrog. About four sets are made in a day. Gear is set with an anchor at each end and sometimes with an anchor in the middle of the set. Some vessels use intermediate weights of about 3 to 10 pounds, and most use swivel gear, which adds weight to the line.

3.4.1.2.2.10 BSAI Sablefish/Greenland halibut Longline Fishery

Description of gear used: This fishery is prosecuted with stationary lines (Figure 3.4-3), onto which baited hooks are attached. Vessels participating in this fishery include a few small to medium (less than 75-foot) catcher vessels and 35 catcher-processors (a.k.a. freezer-longliners) ranging from 90 to 200 feet in length. Gear components that contact the bottom include the anchors, groundline, gangions, and hooks.

For catcher vessels, anchors are two-prong standard anchors weighing 50 pounds, groundlines are generally constructed of 3/8-inch sinking line, 12-foot-long gangions of #72 to #86 twine, and 13/0-14/0 circle hooks. Many of the catcher vessels use snap-on gear with gangions spaced at 3- to 4-foot intervals. On catcher vessels, an average set consists of 20 skates of groundline, with each skate 100 to 150 fathoms longitude. Squid is the preferred bait. The ends of each set are anchored and marked with buoys. The lower shot(s) (33 fathoms each) of the anchor line is (are) made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line are plastic buoys.

For freezer longliners, this fishery uses the same gear used in the cod fishery: 9-mm groundline is employed with 10- to 14-inch gangions spaced 3.5 feet apart, and No. 6 to 14 modified "J" or full circle hooks. Most vessels use swivel gear and autobaiting equipment.

Description of fishery operations: For catcher vessels, the first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The set is not made in a straight line; instead the boat will steer to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. The second anchor is deployed, and the line is left to fish for 5 to 24 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are stripped off the hooks.

For freezer longliners in the Greenland halibut fishery, the gear is set in 250 to 500 fathoms of water, with most of the fishery taking place in 350 to 400 fathoms. The sets are 4 to 5 miles longitude. Normally two sets are made, with subsequent sets leapfrogging. Soak time is highly variable, with a minimum of 5 hours.

In the sablefish fishery, the freezer longliners set their gear in 150 to 600 fathoms (900 to 3,600 feet), with an average depth of 300 to 400 fathoms (1,800 to 2,400 feet). The sets are 3 to 4 miles in length, leapfrogging at roughly the same depth. The freezer-longliner quota is a small part of the overall IFQ. The fishery is conducted in the GOA and in the BSAI. The freezer longliner halibut IFQ quota is taken as bycatch by a small number of freezer longliners engaged in this fishery.

3.4.1.2.2.11 Bering Sea Pacific Cod Jig Fishery

Description of gear used: This fishery is prosecuted with actively fished vertical lines (Figure 3.4-4), onto which baited hooks are attached. Vessels participating in this fishery include small (less than 60-foot) catcher vessels. Gear components include a 8-pound jig weight, a 400-pound test monofiliment mainline, and long shank 10/0 J-hooks that are looped directly onto the mainline. Vessels employ two to four jig machines (Figure 3.4-5) per vessel. Hooks are dressed with colorful segments of rubber surgical tubing and are generally baited with strips of Atka mackerel.

Description of fishery operations: The vessels look for concentrations of Pacific cod and position their vessels to drift over the fish. The machines drop the jig weight to the bottom and may move the jigs up and down slightly to induce the fish to bite. Each jig machine is adjusted to haul back when the right amount of tension is on the line (amount of fish). Machines haul up the fish, which are then removed one by one. The vessels move often to stay over fish concentrations. There is no intentional contact with the bottom, although such contact may occur.

3.4.1.2.2.12 BSAI Pacific Cod Pot Fishery

Description of gear used: The pot cod fishery is prosecuted with square pots (Figure 3.4-34) set on single lines. In 1999, 45 catcher vessels (mostly 60- to 125-foot LOA) and 5 catcher-processors (more than 125-foot LOA) participated in the fishery. The fishery begins at the end of the opilio fishery (March in recent years) and stops in April; a second season occurs during September and October (until the Bristol Bay red king crab fishery starts). Pots used in a directed cod fishery are modified crab pots, which are constructed with a steel bar frame (1.25-inch-diameter) and covered with tarred nylon mesh netting (3.5-inch stretched mesh). Pot sizes range from 6 to 8 feet square, with the average vessel using 7- by 7-foot pots. Each pot has two tunnel openings on opposite sides, with plastic "finger" funnels to retain the fish. The tunnel eye cannot be greater than 9 inches in any one dimension. An escape panel of untreated cotton must be sewn into the mesh. The pot is attached with a 6- to 8-foot bridle, generally constructed of 1-inch-diameter poly line. A 30- to 60-foot surge, constructed of heavy duty line, is attached to the bridle. The lower shots (33 fathoms each) of line are made of 3/4-inch floating poly, and the upper shot of line is made of 5/8-inch sinking line. Attached to the line is a plastic buoy (bag), with an auxiliary buoy attached on a tether line.

Description of fishery operations: The average number of pots per vessel is 120 with an estimated total of 6,000 pots in the fishery. The average number of days of fishing per year is 40 to 50 days. Pots are set and retrieved once every 24 hours. Pots are baited with chopped herring placed in hanging bait buckets in the center of the pot. On most vessels, the pot is tipped into the sea with a pot launcher. The shots of line are thrown overboard, followed by the buoys, and the pot sinks to the bottom. The pot rests directly on the bottom. The pot remains stationary on the bottom until it is retrieved, generally about 24 hours later. Pots are retrieved as follows: the crewman throws a hook between the buoys to get the line. The line is fed into the hauler, and the pot is brought aboard by a crane and placed on the pot hauler. Pacific cod are dumped into totes. The fish are put on ice below decks. The pots are rebaited and reset or stored if they are being moved or it is the end of the season. There is a very small footprint in this fishery (an estimated 0.17-square-mile footprint combined). The average size of a fish is 8 to 9 pounds.

3.4.1.2.3 Geographic Distribution and Intensity of Fishing Effort

Information on BSAI groundfish fishing effort distribution is available from observer data. Historic information on the distribution of the groundfish fisheries is available from Fritz et al. (1998). More recent information was examined specifically for this analysis and is provided in this section.

To understand recent distribution and intensity of fishing effort for the groundfish fleet, the observer data were queried from the North Pacific Fishery Groundfish database for years 1990 to 2002. These data represent vessels that had on-board observers that sampled catch. Each haul was assigned a target based on the composition of the catch of each haul, and the predominant weekly catch. The observer data were separated by region based on these identified targets. The data were brought into a GIS environment using ArcGIS 8.3 ESRI software. The target species represented in longitude and latitude was intersected with a 25 sq. km polygon coverage to clearly represent fishing effort.

The fishery effort was summarized for all years from 1990 to 2002 by the total number of sets. The data are displayed using three natural breaks, which is a methodology used for random distributions. It is based on a Jenk's optimization. The graphics were produced in a format that could be copied in black and white.

3.4.1.2.3.1 Bering Sea Pollock Trawl Fishery

In the EBS, the pollock pelagic trawl fishery takes place at lower effort levels (fewer than 40 hauls/ 25 sq. km summed over the 1990 to 2002 period) throughout the outer shelf (Figure 3.4-16). Concentrations of effort (more than 200 hauls/25 sq. km summed over the 1990 to 2002 period) occurred in one area north and east of Unimak Island and south of St. George Island. The bottom trawl pollock fishery, now prohibited by regulation, occurred north of Unimak Island when it was allowed (Figure 3.4-17). Pollock tend to aggregate mid-water column over areas with sand, sandy silt, and muddy bottom at depths of 35 to 250 fathoms (210 to 1,500 feet).

3.4.1.2.3.2 Aleutian Islands and Bogoslof Pollock Trawl Fishery

In the AI area, the pollock pelagic trawl fishery is not currently authorized. Historically, when it did take place, it was at relatively low effort levels (fewer than 43 hauls/25 sq. km summed over the 1990 to 2002 period) almost exclusively east of Tanaga Island (Figure 3.4-18). Some effort has been more concentrated north of Kanaga and Umnak islands. The bottom trawl pollock fishery, when it was allowed, occurred near Seguam and Atka islands (Figure 3.4-19).

Pollock tend to aggregate in areas with bottom sediments ranging from volcanic sand to hard bottom. Pollock schools may be located close to the bottom in depths of 200 to 1,500 feet, or adjacent to steep edges at this same depth range. Pollock are also fished at depths of 600 to 1,500 feet over much deeper bottom depths (more than 3,000 feet). Pollock aggregate in subterranean canyons on the upflow side.

3.4.1.2.3.3 BSAI Pacific Cod Trawl Fishery

In the EBS, the Pacific cod bottom trawl fishery takes place at lower effort levels (fewer than 102 hauls/ 25 sq. km summed over the 1990 to 2002 period) throughout the deeper portions of the outer shelf (Figure 3.4-20). Concentrations of effort (more than 477 hauls/25 sq. km summed over the 1990 to 2002 period) occurred in one area north of Unimak Island.

In the AI area, the Pacific cod bottom trawl fishery takes place at relatively low effort levels (fewer than 21 hauls/25 sq. km summed over the 1990 to 2002 period) in very few areas throughout the Aleutian chain (Figure 3.4-21). Concentrations of effort (more than 58 sets/25 sq. km summed over the 1990 to 2002 period) occurred north of Amlia Island and on the south sides of Adak Island.

Pacific cod tend to aggregate in areas with sand, sandy mud, and gravel, at depths of 20 to 90 fathoms (120 to 540 feet).

3.4.1.2.3.4 Bering Sea Rock Sole Trawl Fishery

In the EBS, the rock sole bottom trawl fishery takes place at lower effort levels (fewer than 28 hauls/ 25 sq. km summed over the 1990 to 2002 period) throughout the southeast portion of the EBS east of longitude 170º (Figure 3.4-22). Concentrations of effort (more than 93 hauls/25 sq. km summed over the 1990 to 2002 period) occur in the area north of Unimak and Amak islands.

In the spring, the fish tend to aggregate in areas with sand, sandy silt, and muddy bottom at depths of 120 to 300 feet. They are often taken in a mixed Pacific cod fishery. There is no target rock sole fishery outside of spring season when the fish contain roe (January 20 to the beginning of March). The general fishing grounds are from longitude 162º W to longitude 165º W and latitude 56º 10 minutes N to latitude 55º N.

3.4.1.2.3.5 Bering Sea Yellowfin Sole Trawl Fishery

The yellowfin sole bottom trawl fishery takes place at lower effort levels (fewer than 33 hauls/25 sq. km summed over the 1990 to 2002 period) throughout the southeast portion of the EBS east of longitude 170º (Figure 3.4-23). Concentrations of effort (more than 128 hauls/25 sq. km summed over the 1990 to 2002 period) occur in the area east of the Pribilof Islands and in the shallow water area west of Cape Constantine.

In the late spring, the fish tend to aggregate in shallow (less than 150 feet) sandy areas to spawn. At other times of the year, they are occur over sand, sandy silt, and muddy bottom at depths of 100 to 300 feet.

3.4.1.2.3.6 Bering Sea Flathead Sole/Other Flatfish Trawl Fishery

The flathead sole and other flatfish bottom trawl fishery takes place at lower effort levels (fewer than 9 hauls/25 sq. km summed over the 1990 to 2002 period) in many different areas throughout the EBS (Figure 3.4-24). Concentrations of effort (more than 27 hauls/25 sq. km summed over the 1990 to 2002 period) occur in the area east of the Pribilof Islands, north of Unimak Pass, as well as in the deeper waters of the northwest portion of the management area.

Flatfish tend to aggregate in areas with sand, sandy silt, and muddy bottom at depths of 100 to 1,200 feet, depending upon species and season. For example, Alaska plaice are caught in shallow waters (less than 300 feet), but flathead sole and other species are caught down to much greater depths.

3.4.1.2.3.7 BSAI Pacific Ocean Perch and Northern Rockfish Trawl Fishery

In the EBS, the rockfish bottom trawl fishery took place at lower effort levels (fewer than 8 hauls/ 25 sq. km summed over the 1990 to 2002 period) only along the slope areas west and north of the Pribilof Islands (Figure 3.4-25). Concentrations of effort (more than 21 hauls/25 sq. km summed over the 1990 to 2002 period) occurred in the Zhemchug canyon area.

In the AI area, the rockfish bottom trawl fishery takes place at relatively low effort levels (fewer than 16 hauls/25 sq. km summed over the 1990 to 2002 period) in areas sprinkled throughout the Aleutian chain (Figure 3.4-26). Concentrations of effort (more than 122 hauls/25 sq. km summed over the 1990 to 2002 period) occurred on the south side of Seguam Pass.

Rockfish are caught all along the narrow slope area. Bottom types include areas with rocks and living substrates at depths of 175 to 500 m (574 to 1,640 feet) and deeper.

3.4.1.2.3.8 Aleutian Islands Atka Mackerel Trawl Fishery

In the AI area, the Atka mackerel bottom trawl fishery takes place at relatively low effort levels (fewer than 60 hauls/25 sq. km summed over the 1990 to 2002 period) in areas sprinkled throughout the Aleutian chain (Figure 3.4-27). Concentrations of effort (more than 231 hauls/25 sq. km summed over the 1990 to 2002 period) occur on Petrel Bank, on the south side of Seguam Pass, and in the passes on the east side of Amlia, Kiska, and Buldir islands.

Mackerel are caught in areas with volcanic sand, rocks, and living substrates at depths of 125 to 200 m (410 to 656 feet). The fishery occurs in very discrete locations, and tows are generally made in the same locations each year. Mackerel live in many areas where the fishery cannot target them.

3.4.1.2.3.9 BSAI Pacific Cod Longline Fishery

In the EBS, the Pacific cod longline fishery takes place at relatively low effort levels (fewer than 19 sets/ 25 sq. km summed over the 1990 to 2002 period) throughout the outer shelf and upper slope regions (Figure 3.4-28). Concentrations of effort (more than 58 sets/25 sq. km summed over the 90 to 2002 period) occurred north of Unimak Island, south of St. George Island, and along the slope to the west and north of the Pribilof Islands.

In the AI area, the Pacific cod longline fishery takes place at relatively low effort levels (fewer than 25 sets/25 sq. km summed over the 1990 to 2002 period) throughout the Aleutian chain (Figure 3.4-29). Concentrations of effort (more than 58 sets/25 sq. km summed over the 1990 to 2002 period) occurred north of Unalaska and Akun islands, on the north and south sides of Amlia Island, on the south sides of Amchitka and Kiska islands, and all the way out to the west side of Attu Island.

The catcher longline fishery occurs over gravel, cobble, and rocky bottom. In the summer, the fish are found in shallow (150 to 250 feet) waters, but are deeper (300 to 800 feet) in the winter. Catcher-processors fish over sandy/silt bottom in the EBS, but over more rocky bottoms in the AI.

3.4.1.2.3.10 BSAI Sablefish/Greenland Halibut Longline Fishery

In the EBS, the sablefish and Greenland halibut longline fishery takes place at relatively low effort levels (fewer than 11 sets/25 sq. km summed over the 1990 to 2002 period) throughout the slope area (Figure 3.4-30). Concentrations of effort (more than 58 sets/25 sq. km summed over the 1990 to 2002 period) occur in many places along the slope.

In the AI area, the sablefish and Greenland halibut longline fishery takes place at relatively low effort levels (fewer than 11 sets/25 sq. km summed over the 1990 to 2002 period) throughout the slope areas of the Aleutian chain (Figure 3.4-31). Concentrations of effort (more than 39 sets/25 sq. km summed over the 1990 to 2002 period) occurred north of Atka pass, on the south side of Kanaga Island, and on the northeast slope portion of Petrel Bank.

The sablefish/Greenland halibut fishery occurs over silt, mud, gravel, cobble, and rocky bottom at depths of 150 to 600 fathoms.

3.4.1.2.3.11 Bering Sea Pacific Cod Jig Fishery

The pot fishery occurs over gravel, cobble, and rocky bottom. In the summer, the fish are found around rockpiles in shallow (150 to 250 feet) waters, but are deeper (300 to 800 feet) in the winter. Jig vessels fish the area of Shulin Bank between Bishop Point and Akutan, all within 10 nm of Unalaska.

3.4.1.2.3.12 BSAI Pacific Cod Pot Fishery

In the EBS, the Pacific cod pot fishery takes place at lower effort levels (fewer than 24 hauls/25 sq. km summed over the 1990 to 2002 period) in the area north of Unimak, and around the Pribilof Islands (Figure 3.4-32). Concentrations of effort (more than 105 hauls/25 sq. km summed over the 1990 to 2002 period) occurred in one area east of Unimak Island.

In the AI area, the Pacific cod pot fishery takes place at relatively low effort levels (fewer than 65 hauls/25 sq. km summed over the 1990 to 2002 period) sprinkled throughout the Aleutian chain (Figure 3.4-33). A somewhat greater concentration of effort occurred north of Attu Island.

The Pacific cod pot fishery occurs primarily around the west side of Unimak Island and around Unalaska Island, on areas of mud, sand, cobble and low relief hard bottom at a depth range of 50 to 300 m (165 to 985 feet).

3.4.1.2.4 Existing Socioeconomic Conditions

As noted in Section 3.4.1.1.4, a considerable body of information characterizing existing socioeconomic conditions for the BSAI groundfish fisheries, as well as the GOA groundfish fisheries, has been compiled for the concurrent revised draft programmatic groundfish SEIS (NMFS 2003a), which includes an analysis of a broad range of alternatives being considered for these fisheries. Given the overlap in fleets, processing entities, and communities participating in both the BSAI and GOA groundfish fisheries, a combined summary section presenting socioeconomic information applicable to both the BSAI and GOA groundfish fisheries was prepared for this EIS using information from the Groundfish SEIS (NMFS

2003a). That summary treatment is presented in Section 3.4.1.1.4. In addition to that summary section, more detailed information is presented in an appendix to this EIS (the Regulatory Impact Review [RIR]/Initial Regulatory Flexibility Analysis [IRFA], Appendix C). More comprehensive information, in the form of detailed regional profiles, as well as profiles of a range of communities engaged in and/or dependent upon the BSAI and GOA groundfish fisheries, may be found in Downs (2003) and in the "Interim Updates of Sector and Community Profiles," which was posted to the Council website at http://www.fakr.noaa.gov/npfmc/ on January 28, 2002, and is being incorporated by reference into the Groundfish SEIS.

3.4.1.3 BSAI King and Tanner Crab Fisheries

3.4.1.3.1 Summary of the BSAI Crab FMP

The FMP for the Commercial King and Tanner Crab Fisheries in the BSAI was approved by the Secretary of Commerce on June 2, 1989. The FMP establishes a state/federal cooperative management regime that defers crab management to the state of Alaska with federal oversight. State regulations are subject to the provisions of the FMP, including its goals and objectives, the Magnuson-Stevens Act national standards, and other applicable federal laws. The FMP has been amended many times since its implementation, as listed in the adjacent table.

Amendments to the BSAI king and Tanner crab FMP:
1. Defined overfishing.
2 Established Norton Sound superexclusive area registration.
3. Established a Research Plan.
4. Established a moratorium on new vessels.
5. Established a vessel License Limitation Program.
6. Repealed the Research Plan.
7. Revised overfishing definition and updated FMP.
8. Defined EFH.
9. Extended vessel moratorium.
10. Amended License Limitation Program.
11. Rebuilding Plan for C. bairdi.
12. Prohibited retention of sponges and corals (withdrawn).
13. American Fisheries Act sideboards.
14. Rebuilding Plan for C. opilio.
15. Rebuilding Plan for St. Matthew blue king crab.

The king and Tanner crab FMP is a framework plan, allowing for long-term management of the fishery without needing frequent amendments. Therefore, the plan is more general than other FMPs and establishes objectives and alternative solutions instead of selecting specific management measures. Within the scope of the management goal, the FMP identifies seven management objectives and a number of relevant management measures used to meet these objectives. The FMP defers much of the management of the BSAI crab fisheries to the state of Alaska using the following three categories of management measures:

1. Those that are fixed in the FMP and require a FMP amendment to change
2. Those that are framework-type measures that the state can change following criteria set out in the FMP
3. Those measures that are neither rigidly specified nor frameworked in the FMP

Management measures in Category 1 may be addressed through submission of a proposal to the Council. Management measures in Categories 2 and 3 may be adopted under state laws subject to the appeals process provided for in the FMP. Different management measures may be specified for different crab fisheries.

Several measures specified in the FMP and measures implemented by the state of Alaska address habitat conservation concerns. These include a legal gear definition (only pots may be used), limited access, CDQ fisheries, observer requirements, GHLs, pot limits, closed waters, biological escape mechanisms, and other measures.

Management measures implemented for the BSAI king and Tanner crab fisheries, as defined by the federal crab FMP, by category.

Category 1 (Fixed in FMP)	Category 2 (Frameworked in FMP)	Category 3 (Discretion of State)
* Legal Gear	* Minimum Size Limits	* Reporting Requirements
* Permit Requirements	* Guideline Harvest Levels	* Gear Placement and Removal
* Federal Observer Requirements	* Inseason Adjustments	* Gear Storage
* Limited Access	* Districts, Subdistricts and Sections	* Gear Modifications
* Norton Sound Superexclusive Registration Area	* Fishing Seasons	* Vessel Tank Inspections
	* Sex Restrictions	* State Observer Requirements
	* Closed Waters	* Bycatch Limits (in crab fisheries)
	* Pot Limits	* Other
	* Registration Areas	

The most basic fishery management measure employed for crab fisheries is the establishment of catch limits, called GHLs. ADF&G derives the GHLs for most stocks based on annual abundance estimates. The abundance of the major crab stocks is estimated annually from data collected during the NMFS annual EBS trawl survey and published in the NMFS Annual Report to Industry. The crab stocks annually surveyed are Bristol Bay red king crab, Pribilof Islands red king crab, Pribilof Islands blue king crab, St. Matthew blue king crab, EBS Tanner crab, and EBS snow crab. ADF&G derives GHL from these annual abundance estimates following harvest strategies developed for each species. Once the fishery reaches its GHL, ADF&G closes the fishery by emergency order. For crab species not surveyed, ADF&G estimates abundance using pot surveys and fishery information.

The crab fisheries target only large male crabs. Each fishery has a minimum size limit for male crab. All crab fisheries use pot gear. In addition to minimum size and sex restrictions, the state has instituted numerous other regulations for the BSAI crab fisheries. State regulations require vessels to register with the state by obtaining licenses and permits and to register for each fishery and each area. The state has established pot limits for each fishery to limit effort in the crab fisheries.

State regulations also prescribe gear modifications to inhibit the bycatch of small crab, female crab, and other species of crab. Gear modifications include escape rings, tunnel size, and a requirement that crab pots be fitted with a degradable escape mechanism. Like other fisheries, pot fisheries incur some bycatch of incidental fish and crab. Bycatch in crab pot fisheries includes crabs, octopus, Pacific cod, halibut, and other flatfish. However, the vast majority of bycatch in the crab fisheries is females of target species, sublegal males of target species, and non-target crabs. All bycatch of non-legal crabs is discarded at sea. Since pot gear selectively harvests primarily legal sized crab, the crab fisheries do not remove significant amounts of other species from the ecosystem.

Bering Sea/Aleutian Islands king and Tanner crab fishing seasons.

Snow crab	January 15
Golden king crab	August 15
St. Matthew/Pribilof Islands king crab	September 15
Bristol Bay red king crab	October 15
Tanner crab	Oct 15/Jan 15
Norton Sound king crab	July 1

The state establishes fishing seasons following criteria in the FMP. The adjacent table outlines the BSAI crab fishing season start dates. Fishing seasons are established to achieve the biological conservation, economic and social, vessel safety, and gear conflict objectives of the FMP. Season opening dates are set to maximize meat yield, minimize handling of softshell crabs, and meet market demands.

The Magnuson-Stevens Act mandated that the Council and NMFS establish a CDQ program under which a percentage of the TAC of EBS and AI crab fisheries is allocated to the program. The crab CDQ groups receive 7.5 percent of the GHL for the following EBS fisheries: Bristol Bay red king crab, Pribilof red and blue king crab, Norton Sound red king crab, snow crab, and Tanner crab. Crab CDQ fisheries began in 1998. The Council and NMFS defer management authority of the BSAI king and Tanner crab CDQ fisheries to the state, with federal oversight. The FMP provides the state with the authority to establish CDQ fishing seasons, to allocate the crab CDQ reserve among CDQ groups, and to manage crab harvesting activity of the CDQ groups. ADF&G divides the 7.5 percent reserve among the six CDQ groups. The state sets the CDQ seasons after the regular commercial fishery. Sixty-five communities along the EBS are eligible for the CDQ program. These villages aligned into six non-profit CDQ groups. Between three and nine vessels participate in any given CDQ crab fishery.

3.4.1.3.2 Description of the Fisheries and Gears

3.4.1.3.2.1 Bristol Bay Red King Crab Fishery

Description of gear used: This fishery is prosecuted with pots (Figure 3.4-34) that typically measure 7 feet by 7 feet by 3 feet deep, set one pot per line. The total number of pots allowed for a given vessel is determined by a grid that includes vessel length and abundance of the stocks. Vessels participating in this fishery range from 60 to 180 feet long, with most being catcher vessels of medium size (80 to 125 feet LOA). In 2000, 213 catcher vessels and 5 catcher-processors participated in the Bristol Bay red king crab fishery and made a total of 98,694 pot lifts during a 15-day season.

Pots used in this fishery are constructed with a steel bar frame (1.25-inch-diameter) and covered with tarred nylon mesh netting (minimum 3.5-inch stretched mesh). Pots must include escape rings or large mesh (10-inch stretched) to sort out sublegal size crab. Pots are also equipped with a biodegradable panel that will open at least 18 inches. Pot sizes range from 6 to 8 feet square, with the average vessel using 7- by 7-foot pots.

Pots are constructed as follows: There is an outer frame consisting of weight bars on the bottom of the pot, typically 1.5-inch-diameter steel bar stock; a top frame and sides, typically 1 1/8-inch steel bar stock, to provide the structure; and an inner frame of 5/8-inch web bars to support the mesh and separate it from the sides and bottom of the pot. Most of the initial contact with the bottom is borne by the weight bars. A rectangular door is hinged opposite the bridle, to allow easy unloading of catch. Each pot weighs from 500 to 700 pounds dry weight. Each pot has two tunnel openings on opposite sides, typically 9 by 36 inches, with no dimension less than 5 inches and a perimeter of at least 36 inches.

The pot is attached with a bridle, generally constructed of 1-inch-diameter floating polypropylene line. The bridle is attached to floats via a buoy line or warp that consists of a 30- to 60-foot surge line, constructed of heavy duty floating polypropylene and coils of line sufficient to reach the surface. The lower coils of line (33 fathoms) are made of 3/4-inch floating polypropylene, and the upper coil of line is made of sinking line. The length of the floating line is not sufficient to reach the surface. The floating line keeps from fouling on the bottom and the sinking line avoids accidentally fouling in the vessel's propellers. Attached to the top coil is a plastic buoy (bag), with an auxiliary buoy attached on a tether (trailer) line. Pots must carry vessel identification by number and a state licensed serial tag on the buoy denoting the pot limit. These tags must be purchased for each season's fishery.

Description of fishery operations: Red king crabs are taken with pots specifically designed to catch these crabs. Pots are baited with 1 to 2 gallons of chopped herring or other bait placed in hanging bait jars in the center of the pot. The bait jars are thoroughly riddled with small holes to provide water circulation, spreading a plume of scent down-current from the pot. Hanging bait, often consisting of whole Pacific cod or other fish, is also put in the pot, when available. On most vessels, the pot is tipped into the sea with a pot launcher. The coils of line are thrown overboard, followed by the buoys, as the pot sinks to the bottom. The pot rests directly on the bottom. The pot remains stationary on the bottom until it is retrieved. In recent years, the fishery has lasted from 4 to 10 days. Vessels are capable of handling more gear in a day's time than allowed by current pot limits. This produces shorter soak times, generally about 10 to 20 hours, than had been practiced in the past.

Pots are retrieved as follows: the crewman throws a grappling hook between the buoys to get the line. The line is fed into an hydraulic hauler located on a davit, which is positioned over the starboard side of the vessel. The pot is brought to the surface, and a hook is placed in the bridle. The pot and catch are then lifted aboard and placed on the pot launcher. Crabs are dumped into a sorting table or totes and are sorted. Only male king crab with a 6.5-inch or greater carapace width may be retained. All other crabs are returned immediately to the sea. Careful handling is encouraged, and most vessels use a stream of water through a chute to carry the crab overboard with minimal loss or damage. Retained catch is placed in a hold that has circulating sea water and is retained alive until delivery to catcher vessels. Catcher-processors process the catch and freeze it for later delivery. The pots are rebaited and reset, or are stored if they are being moved to a different area or it is the end of the season. In the highly competitive short seasons that are currently the rule, more gear is stacked and moved to different areas than is reset in the original location. This is a function of the short soak times.

The product form produced after processing is sections of legs, claws, and body meat. The carapace, gills, and viscera are removed and ground before discharge. Shore plants are required to have discharge permits in nearshore areas, while at-sea processors disperse their discharge according to Marpol regulations.

3.4.1.3.2.2 Norton Sound Red King Crab Fishery

<u>Description of gear used</u>: This fishery is prosecuted with pots set on single lines. Both square pots (Figure 3.4-34) similar to those of Bristol Bay, but generally no larger than 6 feet in largest dimension, and conical pots are used. Conical pots (Figure 3.4-34) used in this fishery are constructed with a steel bar frame and covered with tarred nylon mesh netting (3.5-inch stretched mesh). Not all conical pots use an inner web bar frame. Conical pot sizes are generally 4 to 6 feet on the base diameter. These pots are built with a smaller diameter top ring and are designed to nest when stacked. Tunnels may be similar to the square pots or consist of a plastic collar approximately 18 inches in diameter and 10 inches high in the top of the pot. Pots may weigh from 70 to several hundred pounds. The pot is rigged with bridle and line similar to that described for the Bristol Bay red king crab fishery, although the depth fished is shallower, so the lines are shorter. Sometimes a sash weight is attached to the line to prevent flotation on the surface rather than using a nylon top coil.

The Norton Sound fishing fleet is unique from the other fisheries managed under the FMP. Due to the small pot limits and the super-exclusive registration area, almost all of the vessels that participate in the Norton Sound fishery are under 32 feet and are from the villages surrounding Norton Sound. The majority of the fleet is converted herring gill net boats, many of which are skiffs that do not have wheel houses or even lights. The Norton Sound winter fishery uses snow machines instead of boats to harvest crab. Approximately 10 snow machines are permitted to harvest king crab commercially by fishing small pots through the ice. A substantial winter subsistence fishery also exists for Norton Sound red king crab.

<u>Description of fishery operations</u>: Pots are baited in a manner similar to that described for Bristol Bay, though hanging bait is used less frequently. On most vessels, the pot is set manually. The line is thrown overboard, followed by the buoys, as the pot sinks to the bottom. The pot rests directly on the bottom. The pot remains stationary on the bottom until it is retrieved. Pots are retrieved with hydraulic haulers or by hand and are handled similar to the method described for Bristol Bay.

Compared to the Bristol Bay red king crab fishery, the Norton Sound crabs are held for much shorter times, if at all, in circulating seawater. The crabs live in cold salt water on the ocean's bottom; the surface waters, from which water for the crab live tanks is taken, are frequently warmer and less saline. A freshwater lens of Yukon River water is a common feature of Norton Sound.

The nearshore area in the vicinity of Nome is closed to commercial fishing in the summer to avoid decreasing the number of crab available to the subsistence fishers.

3.4.1.3.2.3 Pribilof Islands Red and Blue King Crab Fishery

Description of gear used: The gear used in this fishery is similar in every respect to that described for the Bristol Bay red king crab fishery. Compared to Bristol Bay, more vessels of smaller size participate in this fishery. In 1998, the last year the Pribilof king crab fishery was open, 57 catcher vessels made 23,381 pot lifts during the 13-day season.

Description of fishery operations: Pots are baited and fished identically to the method described for the Bristol Bay red king crab fishery.

3.4.1.3.2.4 St. Matthew Blue King Crab Fishery

Description of gear used: The gear used in this fishery is similar in every respect to that described for the Bristol Bay red king crab fishery. Vessels participating in this fishery are mostly catcher vessels 58- to 125-foot LOA. In 1998, the last year the St. Matthew king crab fishery was open, 131 vessels made 89,500 pot lifts during an 11-day season.

Description of fishery operations: Pots are baited and fished identically to the method described for the Bristol Bay red king crab fishery.

3.4.1.3.2.5 Aleutian Islands Red King Crab Fishery

Description of gear used: The gear used in this fishery is similar in every respect to that described for Bristol Bay red king crab. In 1995, four vessels made 2,205 pot lifts. In 1998, the last year the AI red king crab fishery was open, only one vessel made landings of red king crabs. Red king crabs can also be retained in the golden king crab fishery.

Description of fishery operations: Pots are baited and fished identically to the method described for the Bristol Bay red king crab fishery. The area between longitude 179º W and longitude 179º E opened October 25, 2002, for 500,000 pounds GHL. There was a pot limit of 40 pots per vessel less than 125 feet long and 50 pots for longer vessels. In addition, the Alaska BOF has directed that, in the event of a fishery, the area between longitude 172º and 179º W, and inside 3 nm, will be restricted to harvest by vessels of 90 feet or less LOA. Multiple small stocks of red king crab are probably spread over the Aleutians, although this region is currently managed as a single unit. Traditional areas of high abundance are Petrel Bank, Adak, and Amlia islands, and Attu Island.

3.4.1.3.2.6 Aleutian Islands Golden King Crab Fishery

Description of gear used: The gear used in this fishery consists of strings of multiple rectangular pots connected together to form a longline on the ocean floor. Most of the vessels participating in this fishery are catcher vessels under 125 feet longitude There is a single 130-foot, catcher-processor vessel currently participating. Vessels set 400 to 1,800 pots (710 pots each on average). In the 1999/2000 fishery, 17 vessels participated and made 180,169 pot lifts. Pots used in this fishery are constructed with a steel bar frame and covered with nylon mesh netting. A variety of pot sizes is used, largely depending on vessel size and area fished. Pots range from 5 feet 3 inches to 5 feet 3 inches by 32 inches high to 6 feet by 7 feet by 34 inches high. The leading end of the pots' outer frame bars are radii so that they do not snag on the bottom. In addition, the bottom webbing is protected by the outer frame of the pot and does not directly contact the bottom. The difference between golden king crab pots and traditional red king crab pots is that the industry is voluntarily moving toward use of larger webbing on the ends of the pot and the tunnel sides. The newer webbing is between 8.25 inches and 9 inches stretch mesh to reduce bycatch of undersized crab. Pots are set in strings of 20 to 80 pots, each pot connected to the other by 80 to 100 fathoms of floating polypropylene line. Therefore, a single string may be 2 to 5 miles longitude The ends of each string are marked with four buoys. A single buoy on each line is marked with the appropriate ADF&G requirements.

<u>Description of fishery operations</u>: Pots are baited in a manner similar to that described for Bristol Bay red king crab. Golden king crab longlined pots are set at vessel speeds from 5 to 8 knots. Pots are deployed from the deck with ample slack in the floating poly line between pots. Due to the heavy weight of the pots (500 to 1,800 pounds each), pots do not move about on the seafloor. The ends of these strings are weighed down by double weighted anchor pots to ensure that there is no movement of the string on the bottom. Tides and currents have little effect once the pots land on the ocean floor. The average soak time to allow maximum fishing is 3 to 10 days. Pots are retrieved through direct lifting from the seafloor. Pots retrieved from steep slope habitats are lifted away from the slope into the water column rather than being pulled upslope. Similarly, pots on gently sloping or flat terrain are lifted directly from the seafloor (see inset diagrams). Limitations to the strength of the materials used in the longline make it imperative that the vessel be directly above the gear as it is hauled up. Three to four pots may hang in the catenary as the gear is hauled up, with the vessel positioned directly above the pot that is next to leave the bottom. Gear is usually visible on the vessel's depth sounding equipment as it is hauled.

3.4.1.3.2.7 Aleutian Islands Tanner Crab Fishery

<u>Description of gear used</u>: The AI Tanner crab *C. bairdi*) fishery is very similar to the Bristol Bay red king crab fishery, except that the tunnel height cannot be greater than 5 inches, and 5-inch-diameter escape rings are required. In 1994, the last year the eastern district Tanner crab fishery was open, 8 vessels made 6,323 pot lifts. The western district was last open in 1991, when eight vessels made 986 pot lifts.

<u>Description of fishery operations</u>: Fishery operations are identical to those described for the Bristol Bay red king crab fishery.

3.4.1.3.2.8 Bering Sea Tanner Crab Fishery

<u>Description of gear used</u>: The gear used in this Tanner crab *C. bairdi*) fishery is identical to that described for the AI Tanner crab fishery. In 1996, the last year of a commercial EBS Tanner crab fishery, 196 vessels made 149,289 pot lifts during the 16-day fishery.

<u>Description of fishery operations</u>: Fishery operations are identical to those described for the Bristol Bay red king crab fishery.

3.4.1.3.2.9 Bering Sea Snow Crab Fishery

Description of gear used: The EBS snow crab *C. opilio*) fishery is very similar to the Bristol Bay red king crab fishery, except that the tunnel height cannot be greater than 4 inches, and 4-inch-diameter escape rings are required. In 2000, 229 vessels made 170,064 pot lifts during the 7-day opilio fishery.

Description of fishery operations: Fishery operations are identical to those described for Bristol Bay red king crab.

3.4.1.3.3 Geographic Distribution and Intensity of Fishing Effort

3.4.1.3.3.1 Bristol Bay Red King Crab Fishery

Habitat type where fishery occurs: Red king crabs are mostly taken in areas consisting of sandy and silty bottoms at depths of 20 to 80 fathoms (120 to 480 feet). This bottom is typically low relief, without marked features or steep slopes. Occasionally red king crab may be taken on shell hash, gravel, or cobble bottoms. They frequently feed on sand dollars, starfish, clams, scallops, and various marine worms in these areas.

Crabs in their first 1 to 2 years of life generally occur at depths of less than 25 fathoms on grounds characterized by cobble, rock, shell hash, and extensive epifaunal growth in the form of mussels, sponges, compound tunicates and hydroids. They may also be found in association with some species of sea stars and urchins. The commercial fishery tends to concentrate on mature stocks that have segregated themselves by size and sex. The fishery seasons generally avoid mating and molting periods, when males and females are found together.

Bristol Bay red king crab are considered a distinct genetic stock and are managed as a single unit. The area boundaries are established to accomplish this.

3.4.1.3.3.2 Norton Sound Red King Crab Fishery

Habitat type where fishery occurs: Norton Sound red king crabs are taken primarily in areas consisting of sandy and silty bottoms at depths of 25 fathoms or less.

3.4.1.3.3.3 Pribilof Islands Red and Blue King Crab Fishery

Habitat type where fishery occurs: Red king crabs are taken in areas consisting of sandy and silty bottoms at depths of 15 to 60 fathoms (90 to 360 feet). Blue king crabs are generally taken in similar depths, but are more likely found on harder bottom, including cobble, gravel, and occasional rock ledges. Red and blue king crab in the Pribilof Islands are each considered to be a unique genetic stock. Juveniles of both species are found on shallow, hard bottom associated with epifauna. Blue crab juveniles in their first year of life are very frequently found on shell hash.

3.4.1.3.3.4 St. Matthew Blue King Crab Fishery

Habitat type where fishery occurs: Blue king crabs are taken at depths of 15 to 60 fathoms (90 to 360 feet) on hard bottom, including cobble, gravel and occasional rock ledges nearshore, and softer bottom offshore. Blue king crab in the St. Matthew Island fishery are considered to be a unique genetic stock. The early life history of this blue king crab is expected to be similar to the Pribilof Islands blue king crab.

3.4.1.3.3.5 Aleutian Islands Red King Crab Fishery

Habitat type where fishery occurs: Red king crabs are taken in areas of all sediment types at depths of 20 to 100 fathoms (120 to 600 feet).

3.4.1.3.3.6 Aleutian Islands Golden King Crab Fishery

Habitat type where fishery occurs: Golden king crabs are taken in areas consisting of rough, uneven bottom and in compacted sand-cobble sediments at depths of 100 to 400 fathoms (600 to 2,400 feet). Fishery effort is concentrated at the entrances to passes between the islands, particularly in the eastern district. In the western district, the fishery occurs in steep rocky terrain, near passes between islands, and on moderately sloping mud/sand sediments in basins.

3.4.1.3.3.7 Aleutian Islands Tanner Crab Fishery

Habitat type where fishery occurs: Tanner crabs are taken in areas of soft sediment types (silt and mud) at depths of 30 to 110 fathoms (180 to 660 feet).

3.4.1.3.3.8 Bering Sea Tanner Crab Fishery

Habitat type where fishery occurs: Tanner crabs are taken in areas of soft sediment types (silt and mud) at depths of 30 to 110 fathoms (180 to 660 feet). Tanner crabs tend to inhabit the warmer waters of the EBS where summer bottom temperatures exceed 4º C. These occur in western Bristol Bay, the Pribilof Islands, and along the shelf edge.

3.4.1.3.3.9 Bering Sea Snow Crab Fishery

Habitat type where fishery occurs: Snow crabs are taken in areas of soft sediment types (silt and mud) at depths of 40 to 110 fathoms (240 to 660 feet). They are generally found in colder areas of the EBS where summer bottom temperatures are less than 4º C. These areas occur in the mid-shelf region of the central portion of the EBS shelf. In areas of overlap with Tanner crab stocks, hybridization occurs.

3.4.1.3.4 Existing Socioeconomic Conditions

A considerable body of information characterizing existing socioeconomic conditions for the BSAI king and Tanner crab fisheries has been compiled for the concurrent BSAI Crab FMP EIS (not yet released as a public draft EIS), which includes an analysis of the rationalization programs being considered for these fisheries. Information for this section is adapted from that in-process document. More information, in the form of detailed profiles of the range of communities engaged in and/or dependent upon the BSAI king and Tanner crab fisheries, may be found in Downs (2003) and in an appendix to the BSAI Crab FMP EIS (Appendix 3: Social Impact Assessment).

In terms of the catcher vessel or harvest sector component of the fishery, many communities across a very wide area are involved in the fishery, but marked areas of concentration of the fleet are apparent. Table 3.4-12 summarizes the location of the fleet by crab fishery participation for all communities in the 1991 to 2000 period that had two or more vessels (on an annual average basis) participating in the BSAI king and Tanner crab fisheries analyzed in this EIS.

In this document, "PMA crab" is used in data tables as an abbreviated reference to relevant BSAI crab species that are being considered for inclusion in the Proposed Management Alternatives of the concurrent BSAI Crab Rationalization EIS, which are the same species of relevance to this EFH EIS. This section is adapted from the economic and socioeconomic characterization compiled for the crab rationalization document. Crab species and stocks included in the proposed alternatives include Adak (Western Aleutian Islands [WAI]) brown (golden) king crab (*Lithodes aequispina*), Adak (WAI) red king crab (*Paralithodes camtschaticus*), Bristol Bay red king crab (*P. camtschaticus*), EBS opilio (snow) crab (*Chionoecetes opilio*), EBS Tanner crab *C. bairdi*), Dutch Harbor (Eastern Aleutian Islands [EAI]) brown (golden) king crab (*L. aequispina*), Pribilof blue king crab (*P. platypus*), Pribilof red king crab (*P. camtschaticus*), and St. Matthew blue king crab (*P. platypus*). Three additional species or stocks were originally proposed for inclusion in the rationalization program but were later excluded (and do not appear in the quantitative data tables in this section) due to low levels of harvest and/or recent multi-year closures: Dutch Harbor (EAI) red king crab (*P. camtschaticus*), EAI Tanner crab *C. bairdi*), and WAI Tanner crab *C. bairdi*). The rationalization program includes Adak red king crab west of longitude 179º W and excludes it east of this line, but the tables in this section include data for this species/stock from both sides of the line. In the tables, the "non-PMA" crab designation includes all crab species not proposed for inclusion in the rationalization program including, among others, species covered by the BSAI crab FMP but managed under state discretion via an ADF&G commissioner's permit (e.g., AI scarlet king crab [*L. couesi*]), BSAI federal waters fishery crab managed by the state and not included in the FMP (e.g., Korean hair crab [*Erimacrus isenbeckii*]), low-volume, primarily state water fisheries (e.g., Aleutian District Dungeness [*Cancer magister*]), or non-BSAI FMP area federal fisheries (e.g., multiple GOA crab fisheries).

In addition to the communities listed in the table, a fairly long list of communities participated in the BSAI crab fisheries from 1991 to 2000, but these communities averaged fewer than two vessels on an annual basis. In addition to the communities shown in Table 3.4-12, participation of Alaska communities by fewer than an average of two vessels (in order of participation) included Kenai, Seldovia, Yakutat, Seward, Sitka, Akutan, and Soldotna. In Washington, named places within the Seattle-Tacoma Consolidated Metropolitan Statistical Area (CMSA) that included an average greater than two vessels included Seattle, Edmonds, Bellevue, Lynnwood, and Mercer Island; communities in the Seattle-Tacoma CMSA with an average of fewer than two vessels included Milton, Bothell, Mill Creek, Redmond, Snohomish, Kirkland, Stanwood, Woodinville, Shoreline, Mukilteo, Gig Harbor, Issaquah, Kent, Bainbridge Island, Brier, Carnation, Monroe, Vashon, Everett, Federal Way, and Tacoma. Communities in Washington outside the Seattle-Tacoma CMSA that included an average of fewer than two vessels included Chehalis, Cathlamet, Olympia, Sedro Wooley, Edison, Polsbo, Curtis, Manson, Oysterville, Longview, Ocean Shores, Camano Island, Anacortes, Clinton, Nahcotta, Oak Harbor, and South Bend. Communities in Oregon with fewer than two vessels annual average participation included Prineville, Seal Rock, Cascade Locks, Warrenton, Hammond, South Beach, and Depoe Bay. Communities in other states with fewer than two vessels annual participation include Richmond, California; Stryker, Montana; Kailua (Kona), Hawaii; Emmett, Idaho; Swanlake, Montana; Brewster, Massachusetts; Mankato, Minnesota; Lake Havasu, Arizona; and Lakeside, Montana. The number of participating vessels from a given community is not necessarily indicative of the relative volume and value of harvest associated with that community.

Table 3.4-13 provides summary information on the distribution by community of BSAI crab catcher vessels (including catcher-processors) from 1991 to 2000 on an annual average basis in groupings that allow disclosure of associated value data. Not all of the listed fisheries were open each year, and the average number of vessels for the relevant individual fisheries was calculated in this table using years open from 1991 to 2000. For volume and value tables that appear in this section, figures for 1991 to 2000 are annualized on a 10-year basis, no matter how many years each fishery was actually open. The intent of this approach is to approximate the worth or benefit of each fishery to the relevant communities or regions on a comparable basis from 1991 to 2000. The time span 1991 to 2000 was chosen for analysis because this encompasses the entirety of the available data.

As with other summary tables in this section, Table 3.4-13 provides individual species information for only the three largest BSAI crab fisheries (Bristol Bay red king crab, EBS opilio crab, and EBS Tanner crab), a combined total for those three fisheries, a combined total for the other six relevant BSAI crab fisheries, and a combined total for all nine of the BSAI crab fisheries included in the proposed management alternatives analyzed in this EIS. This lumping of the quantitative information from smaller volume/participation fisheries is due primarily to confidentiality considerations. The table row labeled "All fisheries other than PMA Crab" provides a measure of participation of crab vessels in other fisheries. In other words, this row provides a look at dependency of crab vessels on crab compared to other fisheries in which they are engaged.

Due to confidentiality restrictions, availability of information by community is somewhat limited. For Alaska, data are sufficient to provide information on a community basis in Table 3.4-13 and the following table (Table 3.4-14) for Anchorage, Homer, King Cove/Sand Point, Kodiak, and a residual category "other Alaska." For Washington, the Seattle-Tacoma Consolidated Metropolitan Statistical Area (CMSA) is used as the unit of analysis for the greater Seattle area, and an "other Washington" residual category is also used. For Oregon, data for Newport and "other Oregon" are displayed. Due to confidentiality restrictions, data from vessels from states other than Alaska, Washington, and Oregon are not displayed. By examining Table 3.4-13, the relative distribution of the fleet by place of ownership can be determined. The clear dominance of Seattle within the overall harvest sector and of Kodiak within the portion of the fleet owned by Alaska residents is readily apparent for each of the fisheries listed.

Table 3.4-14 provides information on the annual average dollar value of the summary fishery categories by community. This table can also be used to show the relative dependence of local crab vessels on crab itself. For example, crab vessels from King Cove and Sand Point derive almost 32 percent ($2,064,507) of their annual harvest value from fisheries other than the relevant BSAI crab fisheries. No other local Alaska crab fleet derives more than 20 percent of harvest value from non-BSAI crab species. Crab vessels from Anchorage and Homer are more dependent on the relevant BSAI crab species (94 and 89 percent of annual average harvest value, respectively) than other Alaska communities or areas shown (ranging from 68 to 82 percent). Dependency ranged from 71 to 90 percent for Pacific Northwest BSAI crab vessels, but BSAI crab vessels from the Pacific Northwest may also fish outside of Alaska EEZ or Alaska state waters, and that activity would not show up in these data.

In addition to catcher vessels, the BSAI king and Tanner crab fisheries also have a number of catcher-processor vessels as active participants. This sector has far fewer entities than seen in the catcher vessel sector, and a very different distribution pattern by community and region than seen in the vessel sector.

Table 3.4-15 provides an annual average number of catcher-processors by fishery and community of ownership from 1991 to 2000. This table provides an at-a-glance summary of the distribution of the catcher-processor fleet. As shown, the fleet is highly concentrated in the Seattle-Tacoma CMSA, such that potential social or community impacts associated with this fleet under the various alternatives would accrue in large part to the greater Seattle area.

In terms of overall processing, crab processors include catcher-processors, floaters, and shore-based plants spread over a broad geographic base of participation, but a marked concentration of capacity analogous to that seen in the catcher fleet is also present among processors. While there are more than 100 facilities throughout Alaska that process BSAI crab, most crab is processed by the relatively limited set of American Fisheries Act (AFA) qualified processors located in Unalaska/Dutch Harbor, Akutan, and King Cove (NMFS 2002). Table 3.4-16 summarizes the location of operations for processors for all communities from 1991 to 2000 that had an annual average of more than 0.5 processors participating in the BSAI crab fisheries covered by the proposed management alternatives.

In addition to the communities listed in Table 3.4-16, approximately a dozen communities participated in the BSAI crab fisheries from 1991 to 2000, but averaged fewer than 0.5 processors on an annual basis**.** These included Adak and Homer (0.4 average); Cordova, False Pass, and Wasilla (0.3 average); Naknek and Ninilchik (0.2 average); and Chignik and Dillingham (0.1 average). In addition, communities including Kiska (an island in the Rat Islands group in the far western Aleutians), Lost Harbor (a bay on the western side of Akun Island in the Fox Islands group of AI to the east of Akutan), and Tanaga (in the Andreanof Islands group of AI approximately 50 miles west of Adak), three geographic areas without nearby communities/resident populations, are listed as having had some processing activity during this time (each has a 0.1 average). The data set also shows that an annual average of 0.3 processors that do not have a community associated with the processing records operated in the South Region.

As shown in the table, not all processors have designating operating areas and are thus not assigned to communities. These include catcher-processors and a number of (but by no means all) floating processors. Table 3.4-16 is intended to portray the geographic spread of processing by number of processing facilities, but caution is necessary if this information is used for other purposes. The number of participating entities in a community does not necessarily correspond to volume and value of crab processed. For example, while Kodiak is shown as the number three community in terms of average annual number of processors running BSAI crab, this represents a relatively low volume and value of crab compared with some other communities. Similarly, a small number of processors does not equate to an insignificant amount of crab being processed. For example, while specific production figures are confidential, it is common knowledge that the single plant in Akutan is a relatively large operation, so this community may see more crab processed locally than some communities with more processing entities present. Although BSAI crab processing operations take place in Alaska, and Alaska communities derive substantial benefits from these operations (through tax revenues, associated business activity, and so on), ownership and/or management of the large majority of crab processing capacity is concentrated in Seattle. Ownership for a number of the larger processing firms resides overseas, especially in Japan, but Seattle still serves as the center of management activity in these cases.

The amount of community-specific information that can be shown for the processing sector is very limited due to confidentiality restrictions. For example, because other Alaska communities have fewer than four processing entities, only Kodiak and Unalaska/Dutch Harbor can be discussed in stand-alone terms.

Table 3.4-17 provides a count of processing entities by community, on an average annual basis from 1991 to 2000, for Kodiak processors, Unalaska/Dutch Harbor processors, other South Region processors, total South Region processors, and North Region processors. Where location information is available for floating processors, these processors are lumped with shore processors in relevant community totals. Consistent with definitions being used in the concurrent Crab Rationalization EIS, the North Region is defined as that part of the EBS north of latitude 56º 20 minutes N. The South Region is defined as the EBS south of this line, along with the entire GOA. Catcher-processor and some floating processor information does not have the same type of geographically referenced data as the shore processors, so the direct applicability of this information in terms of community impact assessment of processing activity is limited. These data appear under "Processing Activity without Area Designation" in the following table series. As shown, even within these highly aggregated community and region categories, there are few processing entities for many of the cells. While count information is not confidential, value data for entities in the low-count cells must be suppressed due to confidentiality concerns. Table 3.4-18 provides processing value information (in dollars) for the sectors, communities, and species shown in Table 3.4-17. Table 3.4-18 provides a quick reference for the relative level of processing value for the different BSAI crab fisheries by location. Unalaska/Dutch Harbor is clearly the largest processing center; accounting for 68 percent ($76.9 million) of the South Region processing value ($112.3 million) and approximately 34 percent of total processing value ($227.3 million).

In terms of the location of the BSAI crab fishery support sector, Unalaska/Dutch Harbor is the center of support for the fishery within Alaska, with a secondary cluster of businesses in Kodiak. In the smaller participating communities, fleet support is typically provided through processor facilities. In the Pacific Northwest, and for the fishery as a whole, the greater Seattle area is the center for the BSAI crab fishery support service sector.

3.4.1.4 Scallop Fisheries

3.4.1.4.1 Summary of the Scallop FMP

Scallop stocks in Alaska have been managed under an FMP since July 26, 1995, which established a 1-year interim closure of federal waters to scallop fishing to prevent uncontrolled fishing. The management unit is the EEZ of the EBS, AI, and GOA, and it includes weathervane scallops and other scallop species not currently exploited. Scallops are harvested in both state waters and the EEZ, with a combined GHL. The following is a summary of management measures established under amendments to the federal scallop FMP.

Amendment	Date	Action
1	July 1996	Allowed fishing after a 1-year closure of federal waters.
2	Aug 1997	Established a federal scallop vessel moratorium.
3	Dec 1997	Deferred all management (except limited access) to the state.
4	Dec 2000	Established a permanent limited access system.
5	Jan 1999	Designated EFH.
6	2000	Established overfishing levels for weathervane scallops.
7	2000	Prohibited retention of corals and sponges (withdrawn).
8	2000	Established sideboard measures for AFA qualified vessels.

Amendment 1, which allowed scallop fishing under a federal management regime, was approved July 10, 1996, and fishing resumed on August 1. Amendment 1 provided for fishery management through permits, registration areas and districts, seasons, closed waters, gear restrictions, efficiency limits, crab bycatch limits, scallop catch limits, inseason adjustments, and observer monitoring. The state developed most of these regulations before 1995. Dredge size is limited to a maximum width of 15 feet, and only two dredges may be used at one time. In the Kamishak District of Cook Inlet, only one dredge with a 6-foot maximum width is allowed. Dredges are required to have rings with a 4-inch minimum inside diameter. To reduce incentives to harvest small scallops, crew size on scallop vessels is limited to 12 persons, and all scallops must be manually shucked. Dredging is prohibited in areas designated as crab habitat protection areas, similar to the groundfish FMPs.

A vessel moratorium was adopted as Amendment 2. In June 1995, the Council adopted a 3-year vessel moratorium to restrict new entry into the scallop fishery while a more comprehensive plan was being developed. The moratorium was approved as Amendment 2, effective August 1, 1997. To qualify under the proposed moratorium, a vessel must have made at least one landing in 1991, 1992, or 1993, or must have participated for at least 4 years between 1980 and 1993.

Management of the fishery was delegated to the state of Alaska under Amendment 3. All management measures, except limited access, would be implemented by the state. Amendment 4 established a license limitation program that limited the fleet to only nine vessels that would be allowed to fish for scallops in the EEZ. Amendment 8 established a limited amount of scallops that could be taken by one vessel that was qualified as a EBS pollock vessel under the American Fisheries Act. Other amendments to this plan (EFH, and overfishing definitions) were required by the Sustainable Fisheries Act.

3.4.1.4.2 Description of the Fisheries and Gears

Description of fishery operations: Scallop fishing operations involve the following steps: 1) dredge setting, 2) towing for about 45 minutes on the bottom at 4.3 to 4.8 knots, 3) dredge retrieval, 4) dumping the catch on deck, 5) sorting out the scallops to be retained, 6) discarding debris, small scallops, and other bycatch, and 7) repairing gear as needed. The gear is then reset, or the boat moves to a different area. Retained scallops are shucked by a hand-held knife, with the adductor muscle retained and the shells and remaining tissues discarded overboard as the scallops are shucked. The yield of shucked meat is approximately 10 to 11 percent. The discarded shell serves as substrate for settling scallop spat and other marine organisms.

Description of gear used: This fishery is prosecuted with dredges (Figure 3.4-35). Nine vessels are allowed to participate in this fishery, with access limited by a license limitation program. In 2000, there were five vessels using two 15-foot dredges each and two vessels using smaller gear. Vessels used in the fishery range in size from 60 to 124 feet LOA. Maximum horsepower is 800. Vessels fishing outside Cook Inlet are limited by regulations to a maximum of two dredges with a maximum width of 15 feet. The 15-foot dredges weigh 2,400 pounds dry weight each, consisting of a frame and a bag. The 1,900-pound frame rests on two 4- by 9-inch shoes. The bags weigh 500 pounds each. The shoes are changed every 4 to 5 days because they bear most of the weight. In Cook Inlet, only one dredge with a maximum width of 6 feet can be used. Dredges are of a standard 'New Bedford' design, with the steel dredge shoe and 4-inch-diameter steel rings contacting the bottom during fishing. The tops of the bags are constructed of 6-inch-stretched mesh polypropylene netting. Each dredge is attached by single steel wire cable that is operated from a deck winch.

In the past, rubber chafing gear was used to protect the links connecting rings; however, chafing gear is not used at this time because it tends to cause the bag to retain more sediment and small rocks that add to the sorting requirements on deck.

Chafing gear does offer some advantages if it is used. The rate of the wear on the bag depends on the bottom type that is being fished. In Yakutat, for example, the bottom is more sandy and abrasive to the gear, whereas it is a soft, muddy, less abrasive bottom in Shelikof Strait. Not using chafing gear creates more wear and requires more time and effort to replace links. For example, if link wear required 1,500 pounds of replacement links with chafing gear, the link wear associated with the same amount of fishing time without chafing gear would require 3,700 pounds of replacement links, at $1.50 per pound. There are about 30 links per pound, and it requires significant extra crew time to change the links. This represents less time fishing and more time repairing the gear. This extra effort is necessitated by reduced efficiency of the worn bag, causing increased effort for the area. This equals about 68,000 links per vessel, each one hand squeezed. The impression of the scallop fishermen is that the rubber chafing gear has less impact on the bottom.

3.4.1.4.3 Geographic Distribution and Intensity of Fishing Effort

Habitat type where fishery occurs: Weathervane scallops occur in discrete beds in areas 60 to 140 m (average of about 90 m) deep over predominantly clayey silt and sandy bottoms, but they are also found in areas with gravelly sand and silty sand (Turk 2000). Bottom type and depth depends on the area fished. For example, in the EBS, the fishery occurs at depths of 100 to 120 m, but occurs at 60 to 85 m near Kayak Island in the eastern GOA. The fishery occurs from the Panhandle out to the AI and the EBS, with the area fished each year equaling approximately 200 nautical square miles over the entire state. Scallop fishermen tend to avoid rocky or hard bottoms in order to protect their gear. The ADF&G regional information report has not reported any corals taken as bycatch in the scallop fisheries (Barnhart and Rosenkranz, 1999, ADF&G Regional Information Report #4K99-63 1997 and 1998).

"Throughout their range, weathervane scallops are typically found in discrete elongated beds located in areas with high currents and moderate mixing" (Turk 2000).

3.4.1.4.4 Existing Socioeconomic Conditions

The scallop fishery in Alaska began in 1967 in Kodiak Island waters and expanded the following year to Yakutat waters. Since then, Cook Inlet, Alaska Peninsula, and eastern Aleutian waters have been explored, and, following initial utilization levels, overall scallop fisheries have decreased. The Alaska scallop fishery has a history of being sporadic due to exploitation of limited stocks, market conditions, and the availability of more lucrative fisheries (ADF&G website). Prosecuted by catcher-processors, the fishery evolved from a sporadic, low-intensity fishery to one characterized by a highly specialized fleet by 1993. An influx of larger, more efficient vessels from 1990 to 1993 increased harvests and altered the character of the fishery. Of those vessels reporting income from scallop fishing, the percentage of the fleet's total Alaskan fishing income derived from the scallop fishery increased from 57.7 percent in 1983 to 100 percent by 1990. The decreased diversification of scallop vessels into other fisheries represented a shift from a part-time fleet to a dedicated, full-time scallop fleet with greater harvesting efficiency (Shirley and Kruse 1995).

Scallops are generally shucked, washed, and bagged on ice by crew members on a shift basis, while the vessel fishes continuously. Since 1967, when the first landings were made, fishing effort and total scallop harvest (weight of shucked meats) have varied annually. Total commercial harvest of weathervane scallops has fluctuated from a high of 157 landings totaling 1,850,187 pounds of shucked meats by 19 vessels in 1969 to no landings in 1978. Prices and demand for scallops have remained high since the fishery's inception. Table 3.4-19 displays number of vessels, landings, and price per pound by year from 1980 through 1995. The increased harvests in 1990 occurred with new exploitation in the EBS. The reduced 1995 catch was due to implementation of an interim closure in the EEZ beginning in February and ending in August of that year. Only one vessel has made commercial landings of scallops other than weathervanes. In 1991 and 1992, this vessel fished for pink scallops in the Dutch Harbor and Adak registration areas, but the landings data remain confidential (Witherell 1996).

As noted in Section 3.4.1.4.1, Summary of the Scallop FMP, scallop stocks in Alaska have been managed under a federal FMP since 1995. The FMP controls the fishery through permits, registration areas and districts, seasons, closed waters, gear restrictions, efficiency limits, crab bycatch limits, scallop catch limits, in-season adjustments, and observer monitoring. Under the FMP, gear restriction regulations are delegated to the state of Alaska, and most of these regulations were developed by the state prior to 1995. The following paragraphs describe in more detail the interrelationship of FMP controls and the socioeconomic environment of the scallop fishery.

To address a number of concerns with the state of the fishery, the Council established a control date of January 20, 1993. In June 1995, a 3-year moratorium was adopted. Under the moratorium program, 18 vessels fished for scallops from 1994 to 1998 and qualified for a federal moratorium permit. The moratorium itself, however, did little to limit effort. Even during open access, a maximum of 18 vessels (and an average of 9 vessels per year) participated in the fishery since 1980. Of the 18 total vessels qualified, 14 actually applied for and received scallop moratorium permits.

Among other measures, a license limitation program was subsequently undertaken due to characterization that the scallop fishery was overcapitalized because the number of permits under the moratorium program, according to NMFS analysis, allowed too many vessels the opportunity to fish in the waters off Alaska. Furthermore, earlier NMFS documents note that a substantial body of evidence and testimony exists indicating the limited size of the scallop resource, the vulnerability of scallops due to their sedentary nature, and the efficiency of scallop harvesting gear. NMFS analysts concluded that too many vessels targeting the limited scallop resource had had negative economic and socioeconomic impacts on vessel owners, crew, and fishing communities because each vessel's portion of the harvest was too small to earn a profit in the fishery. Thus, the Council saw a need to limit capacity in the fishery.

The Council's break-even analysis, contained in the Scallop FMP Amendment's EA/RIR/IRFA, indicated that approximately six or seven vessels could participate full time in the Alaska statewide scallop fishery at the break-even level (not including Cook Inlet vessels). More vessels could participate if ex-vessel prices for scallop or current annual harvest levels increased. The Cook Inlet fishery appears to be fully capitalized, and perhaps overcapitalized, at the current level of effort (three to four vessels). The break-even analysis showed that the current scallop fleet contained more vessels than necessary to efficiently harvest the resource and that open access has negative impacts on all members of the fleet.

For vessel owners to qualify for a license, they had to hold either federal or state moratorium permits and have made legal landings of scallops in 2 of the 3 years (1996, 1997, or 1998 through 10/9/98). Under these conditions, a total of nine vessels would be issued licenses. Requiring 2 years rather than a single year of participation during the qualifying period served to exclude some vessels with substantial fishing histories in the scallop fishery. Because there were no minimum standards (pounds or fishing time during a year) for participation during the qualifying periods, a vessel could meet the participation standards by landing very small quantities of scallops. Thus, vessels with less participation overall were eligible to receive licenses because they fished more years during the qualifying period, while vessels with more substantial fishing histories, but only 1 year of participation during the qualifying period, would not receive licenses.

Of the nine vessels qualified for a scallop license, seven of these fished statewide in 1996 to 1998 and, therefore, were allowed to continue to fish statewide using two 15-foot dredges. Each one of these seven vessels is fishing in both statewide and Cook Inlet waters. The Council final action restricted the vessels that fished only in Cook Inlet in the qualifying period to using a single 6-foot dredge in all waters. Two qualifying vessels fished only in Cook Inlet during the qualifying period; therefore, they were each restricted to using a single 6-foot dredge, even if they subsequently decided to fish in other waters statewide.

Based on public testimony at the time, each scallop vessel was individually owned, except that one or two companies owned two vessels each. Information on each moratorium-qualified vessel, including name, LOA, home port, area fished between 1996 and 1998 (the license limitation program [LLP] qualifying years), number of years fished, and LLP status is presented in Table 3.4-20.

According to NMFS (Restricted Access Management Program), of the 14 vessel owners who actually applied for and received federal moratorium permits, 7 vessel owners live in Alaska, 3 live in Washington, 3 live in Virginia, and 1 lives in Massachusetts (NMFS n.d.). State regulations require that vessels cannot have more that 12 crew members on board while fishing for scallops, which means that a total of 84 moratorium-era, on-board employment positions are associated with Alaska-owned vessels, 36 are associated with Washington-owned vessels, 36 are associated with Virginia-owned vessels, and 12 with Massachusetts-owned vessels (excluding any in-season crew changes).

Under LLP conditions, a somewhat different pattern is seen through home port data. As shown in Table 3.4-20, of the nine vessels that qualify for the LLP licenses, five are home ported in Alaska; two in Norfolk, Virginia; one in Seattle, Washington; and one in Atlantic City, New Jersey. Of the five Alaska home ported vessels, two are associated with Juneau, and one each is associated with Homer, Eagle River, and Kodiak. Using home port affiliation, of the 108 LLP era on-board jobs, 60 jobs (or 55 percent of the total) are on Alaska home-ported vessels. All Cook Inlet effort (and, therefore, employment) is associated with Alaska home-ported vessels, while statewide effort involves vessels with both Alaska and outside home ports.

The license limitation program went into effect in late 2000. As of 2002, only four vessels were operating in the fishery, using a cooperative arrangement (Witherell, D., 2003, personal communication).

As detailed above, the scallop fishery has undergone a number of recent changes with the establishment of first a moratorium and then a license limitation program. With the current economic data, it is difficult to quantify relative importance of the fishery to the coastal communities. Many crew members come from communities in Alaska (particularly Homer, Seward, and Kodiak), with some crew flying in from the East Coast to participate during the season. Crew members may obtain employment in other fisheries or other sectors of the economy. Vessels that were excluded from the fishery under the LLP may fish for scallops on the East Coast if they have the required permits, or they may buy a scallop license from a qualifying vessel. No information indicates CDQ group involvement in the scallop fishery. While more information is needed to fill in a complete picture of the fishery, available data indicate that the number of communities currently engaged in, or dependent upon, the scallop fishery is limited. While clearly important to the entities and individuals involved, the relative dependency on the scallop fishery in the economically diversified communities of Homer, Seward, and Kodiak (along with Juneau and Eagle River) is likely to be quite low.

3.4.1.5 Salmon Fisheries Off the Coast of Alaska

3.4.1.5.1 Summary of the Salmon FMP

The Alaska salmon FMP was first developed by the Council in 1978, and the Council later revised the FMP in 1990. The management unit is the EEZ off Alaska, east of longitude 175º E, and it includes all five species of Pacific salmon. The following is a summary of management measures established under amendments to the federal salmon FMP.

Amendment	Date	Action
1	Sept 1980	Established multi-measure regulatory changes.
2	Aug 1981	Established multi-measure regulatory package.
3	Sept 1990	Deferred all management to state (except prohibition on net fishing).
4	Dec 2000	Established overfishing definitions.
5	Jan 1999	Designated EFH.
6	Jan 2002	Established revised overfishing levels.

The FMP prohibits fishing with nets in the Alaska EEZ. Additionally, commercial fishing for salmon is prohibited throughout the EEZ, except that troll fishing is allowed east of Cape Suckling. Sport fishing is allowed in all areas. All management measures for the salmon fisheries are delegated to the state of Alaska.

3.4.1.5.2 Description of the Fisheries and Gears

The only fishery allowed in the EEZ under the FMP is the Alaska salmon troll fishery in Southeast Alaska. A review of this fishery is provided in this section. Other salmon fisheries are described in the state-managed fisheries section.

Description of gear used: This fishery is prosecuted with a series of hooks (Figure 3.4-36) that are trolled behind a moving vessel. Two forms of trolling are legal, power troll and hand troll. Gear is restricted in Southeast Alaska as follows: a power troll can have no more than four lines, except west of Cape Spencer and outside 3 miles, where six lines are permitted; a hand troll can have four hand poles or two hand troll gurdies. A typical power troll vessel is 40 feet long and fishes with two to four poles. Attached to each pole are two tag lines, constructed of 300- to 400-pound test line. Main lines (wire) are 400- to 600-pound test stainless steel wire that passes through the tag lines. Each wire is weighed down by a 20- to 65-pound lead cannonball sinker. Cannonballs are attached to the wire with a 200- to 300-pound breaking strap. Mainlines may have up to 10 or more spreads (leaders with hooks) attached. Spreads are placed every 2 fathoms up from the sinker and may number 10 or more spreads per main line. Baited hooks may be used on occasion, but lures, spoons, and hoochies fished behind a flasher are more commonly used.

Description of fishery operations: Salmon trolling is only done in the Southeast Alaska-Yakutat area. Troll fisheries can occur in nearshore and offshore waters. Upon reaching the grounds, the poles are lowered outboard of the vessel, and the wires are attached to tag lines one at a time. The cannonball, attached to the main line, is dropped overboard, and the monofilament spreads are attached to the wire. The lines are set out and retrieved by either a hand crank (hand troller) or hydraulic power (power troller). Vessels troll at speeds of 1 to 3 knots. When a fish is hooked, the fishermen haul back on the wire. Fish are either gaffed and brought aboard if they are of legal size, or shaken off.

3.4.1.5.3 Geographic Distribution and Intensity of Fishing Effort

Habitat type where fishery occurs: Trolling can occur over any bottom type and at almost any depths. Trollers work in shallower coastal waters, but they may also fish off the coast, such as on the Fairweather Grounds. In most situations, the gear rarely contacts the ocean bottom.

3.4.1.5.4 Existing Socioeconomic Conditions

Information on the economic and social conditions surrounding federally managed salmon fisheries off the coast of Alaska has been included within the state-managed salmon fisheries section (Section 3.4.2.5).

3.4.2 Fisheries Managed Under Other Authorities

3.4.2.1 Halibut Fisheries

3.4.2.1.1 Summary of the Halibut Management Program

Pacific halibut fisheries are managed by a treaty between the United States and Canada through recommendations of the IPHC. Pacific halibut is considered as one large interrelated biological stock; but it is regulated by subareas through catch quotas, time-area closures, and since 1995 in Alaska, by an IFQ program adopted by the Council and implemented by NMFS. The fishery has a long tradition, dating back to the late 1800s (Chapter 2). An active recreational fishery occurs as well.

3.4.2.1.2 Description of the Fisheries and Gears

Description of gear used: The commercial fishery is prosecuted with stationary longlines (Figure 3.4-3), onto which baited hooks are attached. Vessels participating in this fishery are primarily small (less than 60-foot) and medium (60- to 90-foot) catcher vessels. Many of the same vessels that participate in the sablefish fisheries also participate in the halibut fisheries. Gear components that contact the bottom include the anchors, groundline, gangions, and hooks. For catcher vessels, anchors are two-pronged standard anchors weighing 50 pounds, groundlines are generally constructed of 3/8-inch sinking line, 8- to 12-foot-long gangions of #72 to #86 twine, and 13/0 to 14/0 circle hooks. Catcher vessels generally use stuck gear (not snap on) with gangions spaced at 30- to 40-foot intervals. On catcher vessels, an average set consists of 10 to 20 skates of groundline, with each skate 100 to 150 fathoms long. Squid and herring are the preferred baits, although salmon may also be used. The ends of each set are anchored and marked with buoys. Intermediate weights are used to minimize the movement of groundline across the bottom. The lower shot(s) (33 fathoms each) of the anchor line is (are) made of 3/4-inch floating poly, and the upper shot(s) of line is (are) made of 5/8-inch sinking line. Attached to the line are plastic buoys and flag poles.

Description of fishery operations: The first anchor is set, and the boat steams ahead with the groundline and baited hooks being set off the stern of the boat. The sets are generally made in a straight line; with some deviation to ensure that the groundline is set in the preferred areas based on depth contour and bottom structure. The second anchor is deployed, and the line is left to fish for 6 to 24 hours depending upon the catch rates. Upon haulback, the groundline is fed through a hauler, and the fish are carefully taken off the hooks.

The halibut resource is healthy, and the total catch has been near record levels. The 1999 coastwide catch totaled 58,026 mt round weight. The breakdown by fishery was for commercial fisheries, 43,270 mt, or 75 percent; recreational fisheries, 5,502 mt, or 9 percent; personal use, 440 mt, or 1 percent; bycatch in other fisheries, 7,779 mt, or 13 percent; and wasted mortality due to fishing by lost gear and discards, 1,035 mt, or 2 percent.

The nature of the Pacific halibut commercial fisheries has changed in recent years. Both Canadian and United States fisheries have moved from an open access fishery with short fishing seasons to an IFQ fishery that lasts 8 months each year. In addition, quota allocations have been implemented for treaty Indian, commercial, and recreational fisheries for Washington to California waters. With closer management of quota allocations, an overall decrease in fleet size has occurred. Vessels licensed to fish in Canada remained at 435, while 1,850 vessels fished in the United States fisheries in 1999, a reduction from 3,400 vessels in 1993.

The assessment of the Pacific halibut stock status was revised in 1996 due to the observed changes in individual growth rates that affected fishing selectivity by gear. The new analyses showed that the exploitable portion of the Pacific halibut stocks apparently peaked at 326,520 mt in 1988 (Sullivan and Parma 1998). The population has since declined slightly and has maintained a biomass in the range of 270,000 to 277,000 mt for the past 5 years. The long-term average reproductive biomass for the Pacific halibut resource was estimated at 118,000 mt (Parma 1998). Long-term average yield was estimated at 26,980 mt, round weight (Parma 1998).

Recent average catches (1995 to 1999) were 29,325 mt for the United States and 6,935 mt for Canada, for a combined total of 36,260 mt for the entire eastern Pacific halibut resource. This catch was 34 percent higher than long-term potential yield, which reflects the good condition of the Pacific halibut resource. At its 2000 annual meeting, the IPHC recommended commercial catch limits totaling 40,714 mt for the 2000 United States and Canadian commercial catch, down from 44,671 mt in 1999. This decline reflects reduced estimates of recruitment and technical adjustments to the hook-and-line survey data.

3.4.2.1.3 Geographic Distribution and Intensity of Fishing Effort

Halibut fishery grounds occur throughout the entire GOA shelf and AI shelf area. In the EBS, halibut are taken in the upper slope area and the shelf area in the immediate vicinity of the Pribilof Islands, St. Matthew, St. Lawrence, and Nunivak islands. Although halibut have been caught as deep as 550 m, they are most often caught between 25 and 275 m.

3.4.2.1.4 Existing Socioeconomic Conditions

The halibut fishery off the coast of Alaska is managed through an IFQ system. The IFQ system was proposed in December 1991 as the best alternative to address problems associated with excess harvesting capacity in the fishery. These problems included short “derby” openings (in most areas, seasons lasted less than a week), lost or abandoned gear (and resulting “ghost fishing”), gear conflicts, safety concerns, poor product quality, low ex-vessel prices, and a host of other issues. Concerns over an IFQ program resulting in consolidation that would undermine the economies of fishery dependent communities prompted the Council to introduce a number of constraints to unrestricted transferability. These include ownership caps, quota share blocking provisions, and owner on-board requirements. This was done to ensure that the characteristics of the fleet that existed prior to the IFQ program (an essentially owner-operator fleet of catcher vessels of various lengths) would not be fundamentally changed by the program. Issuance of quota share to eligible applicants began in late 1994; 1995 was the first year the halibut fishery was prosecuted under the new program. Quota share and the annual IFQ it yields are classified by species, vessel, and regulatory area (NMFS 2002).

Table 3.4-21 presents information on halibut allocations and landings by management area for 2002. The size and nature of the fishery vary considerably between areas. As shown in the table, the number of vessel landings do not directly correspond with area TAC, and both landings and TAC vary a great deal between areas. For example, Area 2C has more than 200 additional landings than Area 3A, but total harvest in 2C is about 14 million pounds or about 63 percent less than the harvest in 3A.

Table 3.4-22 provides information on the larger halibut landing ports in Alaska. As shown, Homer is by far the largest port for halibut in the state, with nearly 73 percent more landings than the next highest volume port (Kodiak). Under IFQ management conditions, good transportation system connections become all the more important due to the shift to proportionally greater emphasis on fresh product, and this has influenced the distribution of landings in the fishery compared to pre-IFQ conditions.

Table 3.4-23 displays information on changes in quota share holdings in the halibut fishery. As shown, there have been large reductions in the number of persons, both Alaskan and non-Alaskan, with quota share holdings since the initial IFQ allocations were issued. The pattern of change for total quota share holdings by region is somewhat more complex.

Table 3.4-24 provides information on quota held by crewmembers. As shown, this represents a substantial portion (19 to 27 percent) of the TAC in all areas.

Table 3.4-25 displays information on the number of vessels landing halibut by area and by season from 1992 through 2002. As shown, the number of vessels participating in the fishery has declined substantially from the pre-IFQ years in all areas, but with different levels of change by area. Area 4D, for example, has seen little change compared to other areas, and the number of vessels with landings in 2002 was greater than two of the three pre-IFQ years shown.

3.4.2.2 State-managed Groundfish Fisheries

3.4.2.2.1 Summary of the Management Program

A comprehensive overview of state-managed fisheries and Steller sea lion considerations was provided by Kruse et al. (2000) in their report titled "Overview of State-Managed Marine Fisheries in the Central and western GOA, AI, and southeastern BS, with Reference to Steller Sea Lions." The state of Alaska manages fisheries for invertebrates, groundfish, herring, and salmon. These fisheries are conducted at various times of the year depending on species and management area. For more information, consult "Commercial Fishing Seasons in Alaska," accessible at http://www.cf.adfg.state.ak.us/geninfo/pubs/seasons/season_2.pdf.

To manage productive fisheries over the long term in accordance with the sustained yield principle in the state of Alaska's constitution, state fishing regulations are in some cases more conservative for target species than associated federal fishing regulations. The Alaska BOF has adopted various policies that guide state fishery management toward this end. Examples include the specification of GHLs, the state equivalent of a TAC, that are well below those permitted in the federal FMP for some species groups. State regulations also prohibit directed fisheries for sharks and skates (except by permit 5 AAC 28.083) and, except for the herring fisheries statewide and capelin in northern Bristol Bay, no commercial fisheries are permitted for forage fishes (as defined in the State FMP) owing to their ecological role in the marine environment. Additionally, spatial, temporal, gear, and vessel size restrictions are enforced in many fisheries.

The Alaska BOF created "Guiding Principles for Groundfish Fishery Regulations" (5 AAC 028.89) which stipulate that state groundfish fisheries are managed conservatively to 1) conserve groundfish resources to ensure sustained yield, 2) minimize bycatch and prevent localized depletion of stocks, 3) protect habitat and other associated fish and shellfish, 4) maintain slower harvest rates by methods and means and time and area restrictions, 5) extend the length of fishing seasons by methods and means and time and area restrictions, 6) harvest the resource in a manner that emphasizes quality and value of the product, 7) use the best available information, and 8) manage cooperatively with the Council and other federal agencies associated with groundfish fisheries.

Another broad conservation measure is the closure of most state waters to non-pelagic trawling (Figure 3.4-37). Most areas are closed year-round, and some areas are closed seasonally in Shelikof Strait. Moreover, a portion of eastern Prince William Sound is closed to pelagic trawl gear during the pollock fishery (5 AAC 28.263) and most of eastern Prince William Sound is closed to all (non-pelagic and pelagic) trawling year-round (5 AAC 39.165; Figure 3.4-38, shaded polygon inside Prince William Sound). These trawl closures were established by the Alaska BOF to protect sea floor habitats, depressed crab populations, and non-target demersal fishes. The non-pelagic trawling ban also reduces the possibility of direct cumulative impacts from state managed fisheries on marine habitat and particularly the benthic community.

The state of Alaska has developed FMPs for Pacific cod, walleye pollock, sablefish, lingcod, and rockfish (Kruse et al. 2000). State management is generally confined to 0 to 3 nm from shore. Exceptions include fisheries for lingcod and black and blue rockfishes, nearshore species for which the state management authority extends to cover their distribution within the EEZ. Technically, lingcod and black and blue rockfishes are not considered "groundfish" under federal definitions owing to their exclusion from federal FMPs. Also, the state manages all rockfishes within state waters of Prince William Sound and Cook Inlet (CI), and the state cooperatively manages the fisheries for demersal shelf rockfishes throughout the EEZ in the eastern GOA, east of longitude 144º W, under the auspices of a federal FMP. State-managed fisheries are confined to specific management areas: the pollock fishery is limited to Prince William Sound, Pacific cod fisheries occur in the Prince William Sound, CI, Kodiak, Chignik, and South Alaska Peninsula areas, and sablefish fisheries occur in Prince William Sound, Cook Inlet, internal waters of Southeast Alaska, and Aleutians Island Management areas (Kruse et al. 2000). Groundfish season openings and closures in state waters are managed to coincide with concurrent federal season openings and closures. These openings in state waters have also been referred to as parallel seasons or parallel fisheries.

Overall, the harvest of pollock, sablefish, and rockfish in the state fisheries is a small portion of the total harvest for these species in the GOA and BSAI (Table 3.4-26). In comparison to the federal harvest from the GOA, harvest from state fisheries in 2000 ranged from 1.1 percent for rockfish to 18.4 percent for Pacific cod of the total harvest. For practical purposes, all of the remaining harvest of other groundfish species is taken in the federal groundfish fisheries. Because harvest of rockfish and sablefish in the state-managed fishery is such a small percentage of the annual total harvest of rockfish and sablefish, it is very unlikely that global-scale cumulative impacts would occur to the marine environment as a result of these fisheries.

3.4.2.2.1.1 State Pacific Cod Fishery

The state developed its FMPs for GOA Pacific cod in 1996, with implementation in 1997. The state manages five Pacific cod fisheries in the GOA in Prince William Sound, CI, Kodiak, Chignik, and South Alaska Peninsula areas. The GHLs for these areas are based upon a percentage of federal ABC apportionment in the western, central, and eastern GOA. The GHL for Prince William Sound is based on 25 percent (changed by the BOF to 10 percent in February 2003) of the annual eastern GOA apportionment, CI is based on up to 3.75 percent of the central GOA apportionment, Kodiak is based on 12.5 percent of the central GOA apportionment, Chignik is based on up to 8.75 percent of the central GOA, and the South Peninsula is based on 25 percent of the western GOA apportionment. For 2003, GHLs were set at levels equal to 25 percent of the federal ABC in management areas in the western and eastern GOA and at 21.75 percent of the federal ABC in the central GOA. In consideration of the developing Pacific cod fisheries in state waters the Council has, since 1996 recommended that the federal Pacific cod TACs in the GOA be set at levels equal to ABC minus the state's GHL levels so that the total harvest of Pacific cod in both the federal and state fisheries would not exceed recommended ABC levels. The state Pacific cod fisheries are still under development, and full utilization of the GHLs has not yet been achieved in all areas of the GOA. In 2000, 18.4 percent of the total GOA ABC for Pacific cod was harvested in the state fisheries, leaving 4,335 mt of the combined state GHLs unharvested. The state does not conduct an assessment of Pacific cod biomass within state waters; however the state conducts an annual trawl survey in the GOA, primarily to assess crab stocks, but also to capture groundfish at additional locations to those sampled in the NMFS trawl surveys. This information, along with dockside sampling results, is provided to NMFS to assist with the assessments of groundfish stocks in the GOA.

Largely to promote sustained seasonal employment in the seafood industry and in agreement with the Alaska BOF Guiding Principles for Groundfish, the state has attempted to slow harvest rates and extend the fishing season. The actual management measures adopted by the state to achieve this objective include the following: 1) gear prohibitions – only pot or jig gear is allowed (no trawls and longlines); 2) gear limits – a maximum of 60 pots per vessel or five jigging machines per vessel are allowed; 3) gear allocations that limit the race to fish – catch is allocated among pots and jigs with a provision to reallocate unused allocations from one gear to the other if the slower paced gear type has not taken its share toward the end of the season; and 4) vessel size limits of no more than 58 feet in the South Alaska Peninsula and Chignik areas. Finally, the state does not open the state-managed cod fishery until 1 to 7 days after the federal fishery has been closed. This delay primarily addresses enforcement concerns, but also spreads out the catches of Pacific cod over time between the federal and state fisheries. As a result of these measures, landings from the state-managed cod fisheries in 1999 were dispersed over March to December (Kruse et al. 2000). Even though the fishing season extends from March through December, most of the harvest in 2001 and previous years has occurred from March through June. In 2001, seasonal apportionments of the federal Pacific cod TAC were adopted. There is no seasonal apportionment of the GHLs in the state fisheries. The state water fisheries close when GHLs are reached or on December 31 each year. For 2001, this meant that in areas where the GHLs had been reached prior to the opening of the federal Pacific cod B season (for example the South Peninsula area), a parallel fishery in state waters would occur, and harvests in state waters would accrue towards the federal TAC. In areas where the GHLs had not been reached prior to the opening of the federal Pacific cod B season (for example possibly Kodiak), there would not be a parallel B season. Rather, the state managed fisheries would continue. Trawl and hook-and-line gear could not be used to target Pacific cod in these areas, and the catch by pot and jig gear would continue to accrue towards the GHLs in these areas.

As stated previously, state fishing regulations are in many instances more conservative for target species than associated federal fishing regulations in adjacent waters. There are some exceptions where state regulations are actually more liberal. However, ADF&G does not have a mandatory observer program. This federal regulation would still apply to federally permitted fishing vessels in state waters but not to fishing vessels without federal permits in state waters. In 2001, 13 vessels over 60 feet LOA surrendered their federal fishing permits following the federal Pacific cod A season so that they could participate in the state waters fisheries without incurring the additional costs of meeting observer coverage requirements. In the same year, 12 vessels under 60 feet LOA returned their federal fishing permits in order to be able to fish within 3 nm of some Steller sea lion haulouts (NMFS 2002; Gharrett, personal communication). In addition, the federal LLP program does not apply to fishing within state waters, and the state water Pacific cod fisheries are open access within exclusive registration areas. The state does limit effort with length and gear restrictions in some areas. New entrants to the Pacific cod fishery may participate in the parallel fishery within state waters during federal seasons and in the state-managed Pacific cod fisheries. In the future, the state may find adjustments to current state regulations necessary to achieve the objective of protracting the fishing season, especially if additional vessels enter the state-managed fishery.

ADF&G established no-fishing zones to 3 nm around Steller sea lion rookeries in 1992 and mirrored most other Steller-sea-lion-related federal closures around haulouts to 3 nm.

3.4.2.2.1.2 State Pollock Fishery

The state-managed pollock fishery occurs within internal waters of Prince William Sound. The state conducts an annual assessment on Prince William Sound pollock. Because reliable estimates of biomass and natural mortality are available, the Prince William Sound pollock GHL is based upon Tier 5 calculations. The GHL is calculated as the product of the biomass estimate, instantaneous natural mortality rate (0.3), and a safety factor of 0.75. For 2001, the estimate of biomass is 6,304 mt which when multiplied by the mortality rate of 0.3 and the safety factor of 0.75 yielded a GHL of 1,420 mt (Bechtol 2000). This is a more conservative harvest strategy than the Tier 3b calculations of ABC and OFL made for the W/C/WYK (western GOA, central GOA, and West Yakutat area) pollock stock. Because it cannot conclusively be demonstrated that the Prince William Sound pollock is a distinct population from the W/C/WYK, nor that the Prince William Sound pollock is completely unassessed by the NMFS EIT and bottom trawl surveys in recent years, the state's GHL for pollock in Prince William Sound has been deducted from the federal ABC for the W/C/WYK pollock stock. For 2002 and 2003, the GHL was set at 1,700 mt.

Prior to 1995, less than 4 mt of pollock were harvested annually in Prince William Sound, principally as incidental catch in other fisheries by vessels using jig and trawl gear. The serendipitous discovery of pollock near Port Bainbridge by transiting pelagic trawl vessels in 1995 led to a harvest of 2,960 mt that year in Prince William Sound.

Since 1996, the season has opened January 20 and closed between January 25 and March 31. Each year, 2 to 11 vessels have participated, and annual harvest has ranged from 1,193 mt to 2,348 mt with an average harvest of 1820 mt (Bechtol 2000).

In 1999, the Alaska BOF directed ADF&G to establish an FMP for pollock in Prince William Sound to reduce potential impacts on the endangered western population of Stellar sea lions. Beginning in 2000, the FMP divides the Inside District of Prince William Sound into three management sections: 1) Bainbridge Section – Inside District waters west of longitude 148º W, 2) Knight Island Section – Inside District waters between longitude 148º W and longitude 147.33º W, and 3) Hinchinbrook Section – Inside District waters east of longitude 147.33º W. The FMP also specifies that no more than 40 percent of the GHL be taken from any single section. To implement this plan, ADF&G targets 30 percent of the GHL from each section with the remaining 10 percent as a buffer in the event of unforeseen changes in harvest rates or incorrect inseason hail weights.

In Prince William Sound, additional time and area closures and spatial apportionments were incorporated into the state management plan for pollock as Steller sea lion protective measures. The Prince William Sound outside district (including Wooded Island, Seal Rocks, Cape Hinchinbrook and Hook Point) is closed to pollock fishing. Additionally, pollock fishing is prohibited during June 1 through November 1 within 10 nm of seven rookeries and haulouts inside Prince William Sound (5 AAC 28.250). This closure time period was based upon similar measures in federal regulations at the time the state rule was adopted. These sites are shown in Figure 3.4-38 with shaded circles.

3.4.2.2.1.3 Sablefish

The following was adapted from ADF&G (1998a). Sablefish fisheries managed by ADF&G in management areas west of longitude 144º W include a limited entry fishery in Prince William Sound and open access fisheries in the CI and AI areas. The Prince William Sound sablefish fishery is managed for a GHL set as the midpoint of a guideline harvest range derived from the estimated size of sablefish habitat and a yield-per-unit-area model (Berceli et al. 1999). The department sets a fishing season length based on the GHL, estimated number of participants, and past catch rates. Rockfish bycatch is limited to 20 percent. In CI, the first GHL was set in 1997 based on the recent 10-year average harvest of 43.5 mt (96,000 pounds) adjusted up or down annually in proportion to the federal TAC set for the CGOA (Trowbridge 1998). In 1999, the GHL was 28.8 mt (63,400 pounds). In 2003, the GHL was 34 mt (75,000 pounds). As with Pacific cod, sablefish are thought to constitute one stock in the GOA, so adjusting the GHL based on TAC changes is thought to be reasonable and conservative. The AI sablefish management area includes all state waters west of Scotch Cap Light (longitude 164˚ 44" W) and south of Cape Sarichef (latitude 54˚ 36" N). The fishery is open May 15 through November 15, unless closed earlier by emergency order when the state GHL is attained. In the AI, the GHL is based on a combination of harvest history, fishery performance, and the federal TAC based on NMFS surveys. In 1999, the GHL was set at 113 mt (250,000 pounds). In 2001, the BOF adopted an FMP for the state-managed AI fishery. Management guidelines include setting a GHL at 5 percent of the BSAI federal TAC; the use of pots, longlines, mechanical jigs, and hand troll; and a logbook requirement. In all management areas, survival of released sablefish is thought to be high, so there is no bycatch allowance for sablefish after the closure of the directed fisheries.

3.4.2.2.1.4 Lingcod

The following was adapted from ADF&G (1998a). The minimum legal size of lingcod is 35-inch total length or 28 inches measured from the front of the dorsal fin to the tip of the tail. The minimum legal size restriction is intended to allow lingcod to spawn at least 2 years before becoming vulnerable to the fishery (Trowbridge 1998). In the Prince William Sound Management Area, the lingcod fishery is split among two districts: the Inside District and the Outside District. For each district, a conservative GHL is established based on 75 percent of the recent 10-year average harvest. For 1999, the GHL for the Inside District was 1.8 mt (4,000 lb), and 10.2 mt (22,500 pounds) was set for the Outside District. In Prince William Sound, lingcod are primarily caught as bycatch mainly by longline vessels. In CI, a GHL was set at 15.8 mt (35,000 pounds) as 50 percent of recent 5-year harvest, and only mechanical jig and hand jig (hand troll) gear may be used to target lingcod. During the open fishing season in Prince William Sound and CI, lingcod may be retained as bycatch in other directed fisheries in an amount that does not exceed 20 percent by weight of the directed groundfish species aboard the vessel.

In the WGOA, lingcod are taken largely incidental to other fisheries. Therefore, no GHLs are set, and harvests are small. In the Kodiak and Chignik areas, there are no gear restrictions, and lingcod over the size limit may be retained from July 1 through December 31. The South Alaska Peninsula is the western range limit of the species, so no specific lingcod regulations exist in that area. Like sablefish, survival of released lingcod is relatively high. After the closure of the directed lingcod fishery, therefore, they cannot be retained as bycatch in any other fisheries.

3.4.2.2.1.5 Rockfish

The following was adapted from ADF&G (1998a). The Prince William Sound rockfish management plan, adopted by the BOF in 1992, includes three main components: 1) a 68-mt (150,000-lb) annual harvest cap for all species, 2) bycatch allowance for low-level retention once the directed fishery is closed, and 3) vessel trip limits. The small trip limit of 1.4 mt (3,000 lb) per 5-day period maintains a slow-paced fishery. Unlike sablefish and lingcod, most rockfish die when discarded at sea. Therefore, a low (10 percent) bycatch allowance set by EO provides for retention of unavoidable bycatch rockfish, while not providing an incentive to target rockfish after the closure of the directed fishery. The GHL is set relative to average harvests sustained over time similar to the Tier 6 approach summarized by DiCosimo (1998) for groundfish fisheries lacking stock assessment data under federal management. In 1999, the BOF designated Prince William Sound as a bycatch-only fishery with full retention. All rockfish above the allowable bycatch rate set for each directed fishery (Pacific cod – 5 percent, sablefish – 20 percent, and all others – 10 percent) must be donated or sold in the name of the state of Alaska.

The Cook Inlet Area Rockfish Management Plan is virtually identical to the Prince William Sound management plan with a 68-mt annual harvest cap and low bycatch allowances. In mid-1999, however, new regulations that restricted gear to jig only became effective, and the BOF set a season opening date of July 1. Vessel trip limits are set by district. In the Cook Inlet District, a fishing vessel may not land or have on-board more than 0.45 mt (1,000 pounds), or 1.81 mt (4,000 pounds) in the case of the North Gulf District, of all rockfish species within 5 consecutive days. When the directed fishery is closed, bycatch limits for rockfish are set at 10 percent or less.

3.4.2.2.2 Description of Fisheries and Gears

The fisheries are described in the previous sections. The gear used in state fisheries is virtually the same as that used in federal fisheries for these species (or, in the case of lingcod, virtually the same as other longline gear). However, no non-pelagic trawling is allowed in large areas of state waters (0 to 3 nm). For additional information see ADF&G (1998a).

3.4.2.2.3 Geographic Distribution and Intensity of Fishing Effort

The geographic distribution and intensity of the state fisheries are described in the previous sections. For additional information on geographic and spatial distribution of state-managed species, see ADF&G (1998a).

3.4.2.2.4 Existing Socioeconomic Conditions

The state of Alaska, through ADF&G, is responsible for the management of all groundfish occurring within state waters. Groundfish is defined as any marine finfish except halibut, osmerids (smelts), herring, and salmonids. In addition to these fisheries, ADF&G is responsible for management of black rockfish and lingcod in both state and federal waters because these species are not considered groundfish under federal fisheries management plans. In the eastern GOA, demersal shelf rockfishes are managed by ADF&G in federal waters under the authority of NMFS.

As part of its groundfish management activity, ADF&G has divided state waters into three regions, as shown in Figure 3.4-39. Each region is further divided into groundfish management areas. The regions consist of the Southeast Region, encompassing the eastern GOA and the internal waters of southeastern Alaska; the Central Region, encompassing Cook Inlet and Prince William Sound; and the Westward Region, encompassing Kodiak, Chignik, the South Alaska Peninsula, and the BSAI. The groundfish harvest, in terms of targeted species, varies in each of the regions mentioned above due to differing oceanic conditions.

Commercial groundfish exploitation in Alaska waters became significant in the early 1900s with the harvesting of sablefish in the internal waters of Southeast Alaska (O'Connell et al. 2002). Groundfish species are exploited both through direct harvest and as bycatch. Over time, the number of harvested groundfish species has expanded in response to regulation, fluctuation in fish stocks, and changing market conditions. By 1945, seasonal catch limitations were imposed.

Two species, sablefish and Pacific cod, dominate the commercial groundfish harvest in state-managed waters. Sablefish continues to dominate the groundfish industry in the Southeast Region, typically accounting for 80 percent of the total groundfish ex-vessel catch value (O'Connell et al. 2002). Sablefish is the most valuable groundfish harvest in state waters. In 2001, for instance, the sablefish catch accounted for $11,061,064 of the total groundfish harvest ex-vessel value of $18,710,886 (ADF&G 2002c). The groundfish industry in the Southeast Region is centered in Sitka.

Groundfish harvest in the Westward Region is dominated by Pacific cod, which were landed in significant numbers beginning in 1964 (Jackson and Ruccio 2001). Westward Region groundfish industry fishing ports include Sand Point, Chignik, King Cove, and Kodiak, with Kodiak being the most important (Jackson and Ruccio 2001). GOA groundfish are also delivered to Akutan and Dutch Harbor.

Statistics for groundfish harvests in state-managed fisheries are reported annually for statewide fisheries and seasonally for specific fisheries. Catch and value data for state-managed fisheries are accessible on the Internet. Table 3.4-27 presents the tonnage and ex-vessel value of groundfish harvested from state-managed fisheries in 2001. Total ex-vessel value in all four regions equaled $17.9 million, with slightly more than half (51.7 percent) accounted for by the Southeast Region sablefish fishery.

3.4.2.3 State-managed Crab Fisheries

3.4.2.3.1 Summary of the Management Program

The following was adapted from Kruse et al. (2000). Some crab fisheries in federal waters in EBS and AI are managed jointly by ADF&G and NMFS under species-specific FMPs, while the rest are managed by the state with its own FMPs developed in accordance with federal FMPs. An observer program for vessels that process crab at sea ensures adherence to crab fishing regulations and also gathers scientific information for management.

Because the federal FMP delegates most management of BSAI crab fisheries to the state, and because there is no federal FMP for the GOA, the BOF has developed management plans, in accordance with BOF policy on crab management, that describe specific harvest strategies and other management measures implemented by ADF&G to regulate crab fisheries off the coast of Alaska. The harvest strategies are developed to strive to keep sufficient spawning biomass for stock productivity by controlling the removal of mature males. Harvest rate and GHL are determined for each exploitable stock. Minimum stock size thresholds have been determined only for those stocks having sufficient fisheries and biological data, as well as adequate stock assessment analysis. If the preseason standing stock size falls below threshold, and in some fisheries if the preseason estimate of GHL is lower than the minimum acceptable GHL, the fishery is closed for the entire season. If the stock is above threshold levels, then harvest rate is calculated by a stair step or linearly increasing function of standing stock size up to a maximum rate (ADF&G 1999). To avoid disproportionate harvest of legal males within the GHL, legal male harvest rate is capped at 50 percent in most fisheries. Incidental mortality of crab in other fisheries (trawl, groundfish pot, and dredge) is limited by bycatch caps as a percentage of the crab abundance and closed areas.

Most crab fisheries are managed by sex, size, and season regulations, as well as a GHL determined from either stock biomass estimates or long-term mean harvests except Dungeness crab, which is managed by sex, size, and season (3S) regulations only. In addition, fisheries performance within a season is monitored and, if the fishery is expected to exceed the GHL before the declared season closure date, then the season is closed by the ADF&G commissioner's emergency order. Only male crabs above the minimum legal size can be retained for marketing, and sublegal crab must be released unharmed as soon as possible. Single-sex harvest has been enforced since the late 1940s to protect the reproductive potential of mature females. Specific fishing seasons are set to avoid crab mating and molting periods and to optimize meat recovery and price.

3.4.2.3.2 Description of the Fisheries and Gear

The following was adapted from Kruse et al. (2000). Crab pots (Figure 3.4-34) are the legal gear allowed to harvest crab in commercial and non-commercial fisheries. However, crab rings are also allowed in Dungeness and some Tanner crab fisheries. Harvest gear for personal use consists of crab pots or SCUBA gear. Incidental catch of crabs occurs in trawl, dredge, and groundfish pot fisheries. However, this bycatch cannot be legally retained.

Crab pot design differs by species, but all pot gear must have a biodegradable seam, panel, or other device that renders the pot incapable of holding the catch for more than 30 days (6 months in the case of Dungeness crab) if the gear is lost at sea. In addition, pots must have the required number of escape rings at specified heights from the base to allow sublegal crabs to escape. Dungeness crab pots are rounded (1.1 to 1.5 m diameter) while king and Tanner crab pots are typically larger and rectangular in shape (1.8 m by 1.8 m to 2.4 m by 2.4 m with a height of 0.8 to 0.9 m). King crab pots are often modified for use in Tanner crab fisheries by reducing the tunnel size to suit the entry of smaller size legal crab (ADF&G 1999). Pots are baited with chopped herring or other fish and deployed on a single buoyed line, except in the golden crab fishery in the AI where a minimum of 10 pots are longlined together owing to strong ocean currents. Single-line pots are placed in the water using a hydraulic pot launcher and set in rows that may run from dozens to more than 100 pots. Longlined pots are set using a ramp over the stern of the vessel. The depth fished varies with target species. Pot soak time has declined over the years from as high as 3 days to 12 hours as the duration of fishing season length has shortened, and pot limits have been imposed. Pots are hauled using a hydraulic crab block mounted near the gunnel. Once aboard, the pot’s contents are sorted, and female and sublegal male crabs are returned to the sea. Legal crabs are retained in live tanks with a continuous flow of seawater. In the case of catcher-processor vessels that have no live tanks, crabs are processed immediately aboard the vessel.

3.4.2.3.2.1 Red King Crab

The following was adapted from Kruse et al. (2000). Although red king crab fisheries existed in many regions of the central and western GOA, AI, and EBS, CI, Kodiak, AI, and Bristol Bay (BB) fisheries have contributed the largest volumes to the total landings. CI red king crab have been harvested since late 1930s, but catch records are available only from the 1960/61 season. The crab fishery occurred either in the Southern or the Kamishak/Barren islands districts with very little fishing activity recorded in the Outer district and none in the Eastern district. Catch peaked at 3,908 metric tons (mt) in 1962/63 and declined in the latter half of 1960, primarily due to lack of facilities available for processing as a result of 1964 earthquake damage to major plants in Seldovia. Although catches improved in the 1970s, stock abundance declined drastically in the early 1980s, perhaps due to heavy fishing (17 to 89 vessels), and the commercial fisheries in the Southern district and the Kamishak/Barren and Outer districts have been closed since the 1982/83 and 1984/85 seasons, respectively. The 1983/84 season produced only 87 tons by 17 vessels. Kodiak red king crab has been harvested since 1936. Proper catch records, however, have only been available since the 1960/61 season. Catches peaked in 1965/66 at 42,834 mt with 177 vessels and systematically declined to 3,960 mt by the final season, 1982/83, despite a number of management measures (such as minimum legal crab size and pot limits) taken to arrest the decline.

The AI fishery occurred in two registration areas: Adak (an area west of longitude 171º W) and Dutch Harbor. Domestic fisheries for red king crab started in 1961 in both areas. The Adak Island area harvest reached a peak of 9,613 mt with 18 vessels in 1964/65, while peak production in Dutch Harbor area occurred in 1966/67 with a yield of 14,902 mt by 27 vessels. The catches in both areas fluctuated over the years, and the Dutch Harbor fishery declined to a low harvest level of 195 mt by 1982/83. This area has been closed since then. The Adak area fishery occurred annually until the 1995/96 season when only

18 mt was landed. In order to obtain information on red king crab abundance, ADF&G opened a limited commercial fishery in two areas of the AI in 1998/99 with a GHL of 7 mt. Closed waters included Petrel Bank. Out of three vessels registered for fishing, only one reported any landings.

The BB red king crab fishery, the largest of all, has persisted since the Japanese began harvesting crab in the EBS in 1930. Although the continuity was punctuated by a number of fishery closures due to low abundance, landings peaked at a record high of 58,944 mt from 236 vessels in 1980. Since then, stock size declined sharply through the early 1980s and remained depressed in the 1990s, although the number of vessels participating in the fishery remained high, 89 to 302 vessels.

3.4.2.3.2.2 Blue King Crab

The following was adapted from Kruse et al. (2000). The St. Matthew and Pribilof Islands districts are the two major blue king crab fishing areas. In 1965, the Japanese developed a blue king crab fishery in the Pribilof district. The United States fleet first participated in this fishery in 1973, when they fished near St. George and St. Paul islands. In the 1970s, blue king crab were taken primarily as bycatch in the snow and Tanner crab fisheries. The catch peaked in 1980/81 at 4,976 mt by 110 vessels. The effort peaked at 126 vessels in 1983/84. Thereafter, the catch and effort sharply declined until the fishery was closed in 1988/89 due to very low abundance. Some of the landing records in the 1990s were mixed with red king crab catches; therefore, the blue king crab catches were underestimated during this period. A commercially viable blue king crab resource was discovered around St. Matthew Island in the 1970s, and United States vessels started exploiting this population in 1977. The harvest peaked at 4,288 mt with an effort of 164 vessels in 1983. The catch declined thereafter and stabilized at two low levels: from 1986 to 1990 at a low catch range of 455 to 783 mt with an effort range of 31 to 69 vessels and from 1991 to 1998 at a slightly higher catch range of 1,122 to 2,109 mt with 68 to 174 vessels.

3.4.2.3.2.3 Golden King Crab

The following was adapted from Kruse et al. (2000). Following the collapse of red king crab, interest emerged to exploit other species, such as golden king crab. Golden king crab were landed in many areas, either as bycatch in red and blue king crab fisheries, or as catch in a directed fishery. Fisheries in AI registration areas (Adak and Dutch Harbor) accounted for most of the landings, whereas the Prince William Sound fishery produced small catches. Golden king crab inhabit deeper waters than red or blue king crab. In central and western Prince William Sound, king crab catches have been recorded since 1960, but species-specific catch recording only started in 1979/80. With the decline in red and blue king crab landings, a directed fishery for golden king crab started in the 1980s. However, the golden king crab stock in Prince William Sound is small. Catch and effort peaked at 67 mt and 31 vessels, respectively, in 1982/83; thereafter, they declined rapidly. Only two vessels fished in the last season, 1991/92. Since then, the fishery has occurred sporadically in some seasons. A directed fishery for golden crab started in Al registration areas in the 1981/82 season. Between 1981 and 1995, an average of 49 vessels in Adak and 18 vessels in Dutch Harbor participated in the fishery. Peak harvest occurred in Adak in the 1986/87 season (5,805 mt by 62 vessels) and in Dutch Harbor during 1995/96 (904 mt by 17 vessels).

3.4.2.3.2.4 Tanner Crab

The following was adapted from Kruse et al. (2000). Tanner crab resources were exploited in many areas, but Prince William Sound, CI, Kodiak, Alaska Peninsula (Chignik and South Peninsula), and EBS fisheries are historically most important. The Tanner crab fishery in Prince William Sound and adjoining GOA waters began in 1968 and was the main shellfish fishery in that region before it collapsed. The fishery peaked at 6,318 mt in 1972/73 and declined to 215 mt in 1988 before it was closed. From 1976 to

1988, the effort ranged from 14 to 51 vessels. Despite closure of the commercial fishery, sport, personal use, and subsistence Tanner crab fisheries persisted at a low level until 1999, when they were closed due to continued low crab abundance. A number of reasons were given for the collapse of the Prince William Sound fishery (Trowbridge 1996): overexploitation of immature and legal males, illegal harvest of females, lengthy fishing season (7 months from 1974 to 1981), and warm seawater temperatures. The Tanner crab fishery in CI occurred in six districts: Southern, Kamishak, Barren Islands, Central, Outer, and Eastern (Trowbridge 1996). Catch recording began in 1968, and the catch peaked at 3,614 mt in 1973/74. Landings from the Eastern District were smaller compared to those of the other districts. The total number of vessels in all districts ranged from 7 to 137. Because of the decline in abundance, the commercial fishery has been closed since 1995. However, sport and personal use fisheries occur in the Southern District; these fisheries harvest up to 10 percent of legal male crabs. With the decline of the red king crab stock in Kodiak waters, fishermen targeted Tanner crabs among other crabs. The domestic fishery began in 1967. Development of this fishery was slow due to a number of reasons (ADF&G 2000a), the most important one being low consumer acceptance. By 1972, market conditions had improved, and the fishery grew to a peak of 15,096 mt harvested by 148 vessels in the 1977/78 season. The harvest began to decline in the late 1970s and early 1980s with increasing effort (148 to 348 vessels), which prompted the BOF to enforce a number of management regulations including pot limits and exclusive fishing areas. Due to the persistent decline of crab stocks around the Kodiak area, the commercial fishery has not been open since the 1993/94 season. Tanner crab fisheries in the Peninsula area occurred in two districts: Chignik and South Peninsula. The fishery in the Chignik District started in 1968. The harvest peaked in 1975/76 at 3,142 mt from 35 vessels. The number of vessels engaged in the fishery ranged from 6 to 48. As observed in other GOA crab fisheries, the harvest progressively declined to an historic low (147 mt) in 1989, and the commercial fishery has remained closed since 1989. The South Peninsula fishery started in 1967 and developed to produce a maximum yield of 3,939 mt with an effort of 48 vessels. Thereafter, harvests declined systematically to a low of 479 mt in 1989, and no fishery has occurred since then. The number of vessels engaged in this fishery ranged from 17 to 74.

3.4.2.3.2.5 Snow Crab

The following was adapted from Kruse et al. (2000). Snow crab, being a more northerly species, were harvested only in the EBS and have been fished since 1977, initially incidental to Tanner crab harvest. The directed fishery started in 1981 with the decline of Tanner crab harvest. In terms of landed weight, this was by far the largest crab fishery in Alaska waters. The fishery grew progressively with increasing catch and effort, and the catch peaked in 1991 at 149,073 mt harvested by 220 vessels. Thereafter, the catch started to decline and picked up in 1998 to reach a harvest of 110,379 mt by 229 vessels. The number of vessels operating in this fishery ranged from 52 to 273 from 1978 to 1999.

3.4.2.3.2.6 Korean Hair Crab

The following was adapted from Kruse et al. (2000). Historically, the Korean hair crab fishery in the EBS occurred in the Pribilof district. Japanese fleets exploited this fishery in the 1960s, and the United States fleet entered in 1978. Throughout the 1980s, they were caught as bycatch in Tanner crab fisheries. As the interest in this population increased in the 1990s, ADF&G began to manage this fishery under conditions of a commissioner's permit. During the historical development of this fishery, effort and harvest reached a maximum of 67 vessels and 1,107 mt in 1980. Effort dropped from 1987 to 1990 as a result of stock declines. In the 1990s, the harvest reached a peak of 1,059 mt in 1993/94. The number of vessels operated in this fishery ranged from 2 to 99, but it was fewer than 10 in nearly half of the seasons. Since 1995, both the effort and the GHL have declined as a result of stock decline.

3.4.2.3.2.7 Dungeness Crab

The following was adapted from Kruse et al. (2000). Historically, Dungeness crab harvests have been reported from the Prince William Sound, CI, Kodiak, Alaska Peninsula, and Al districts, but the first four areas have the longest history of landings. The Dungeness crab fishery in Prince William Sound occurred in two regions: the Inside and the Outside districts. The major fishery occurred within Orca Inlet in the Inside District and in the Copper River delta and Controller Bay areas in the eastern section of the Outside District. In 1987, split regulatory seasons were adopted in the Outside District with open seasons from March 20 to May 20 and July 25 to December 31 to protect softshell males. The total Prince William Sound catch peaked at 931 mt by 63 vessels in 1978. Peak catches in the Inside and Outside districts occurred in 1960 and 1981, respectively (Berceli and Brannian 2000). Historically, the total Prince William Sound effort ranged from 2 to 67 vessels. Because of depressed stock levels, the fishery has been closed since 1980 and 1993 in the Inside and the Outside districts, respectively. Besides overfishing, sea otter predation (only on the Orca Inlet stock) and adverse climatic change were likely causes identified for non-recovery of Prince William Sound stocks (Berceli and Brannian 2000). Cook Inlet Dungeness crab catches have been recorded since 1961, and most catches came from the Southern District. Split fishing seasons in the Southern District (Kachemak Bay) from July 15 through December 31 and from January 15 or the beginning of the Tanner crab fishing season (whichever is later) through March 15 were designed to protect softshell crab. The catch peaked at 967 mt by 72 vessels in 1979. Effort varied from 1 to 108 vessels during the history of this fishery. The commercial fishery in the Southern District has been closed since 1991 and in all other districts since 1997 because of low stock levels. Sport and personal use fisheries continued through mid-1998 when they were closed due to low stock levels. Most non-commercial harvest occurred in Kachemak Bay east of Homer Spit with little effort in other districts (Trowbridge et al. 2000). Parts of the Kodiak District and the northern area have an open season from May 1 to January 1, and the southern area has an open season from June 15 to January 1 (Ruccio and Worton 2000). The Dungeness crab fishery in Kodiak started in 1962, and the maximum catch of 3,098 mt was harvested by 43 vessels in 1968. The number of vessels participating in this fishery varied from as low as four to as high as 125, but fewer than 25 vessels have been operating since 1995. Stock abundance fluctuated with the change in effort and recruitment. Lower market value contributed to low effort in many years in the late 1990s. Dungeness crab harvests have been recorded along the Alaska Peninsula since 1968, but landings have been sporadic. The highest landing was 571 mt, achieved in 1968. In the 1980s, catch and effort increased as a result of the decline in king crab harvest and stronger market for Dungeness crab, and the harvest peaked to 545 mt with 132 vessels in 1983. The numbers of vessels operated during the 1990s was low; it varied from fewer than 3 to 24. Few seasons recorded confidential landings (years in which fewer than four vessels made landings), which included 1999, because fewer than three vessels reported landings.

3.4.2.3.2.8 Grooved Tanner Crab, Triangle Tanner Crab, and Scarlet King Crab

The following was adapted from Kruse et al. (2000). Since the 1990s, grooved Tanner crab and triangle Tanner crab were harvested in the Alaska Peninsula, Al, and EBS areas, mostly as bycatch in the crab fisheries. Triangle Tanner crab were caught as incidental catch in the grooved Tanner crab fisheries in the three areas. The grooved Tanner crab harvests in the Alaska Peninsula, AI, and EBS areas ranged from 25 to 456 mt. Few (three to eight) vessels were involved in this fishery in each area, and there were no landings since 1997 although fisheries were open. As an example of the size of this fishery, four vessels reported a 22 mt harvest in 1995 in the EBS area. Scarlet king crab were harvested as bycatch in the golden king crab and deep-water Tanner crab fisheries in the Al area. Since 1992, annual harvest has ranged from 3 to 29 mt, and two to eight vessels engaged in this fishery.

3.4.2.3.3 Existing Socioeconomic Conditions

The most commercially important crab species in Alaska, king, Tanner, and snow crab, are managed under a federal FMP. Crab species included in state-managed fisheries consist of Dungeness and Korean hair crab.

Dungeness crabs inhabit estuaries and the open ocean at depths ranging from the intertidal zone to in excess of 50 fathoms. In Alaska, Dungeness crabs occur from the Dixon entrance to Unalaska Island (ADF&G 1985). The largest concentrations occur in the Kodiak and South Peninsula areas of the Southwest Region, and in Lower Cook Inlet and Prince William Sound of the Southcentral Region. Dungeness crabs are harvested almost exclusively for the United States market, with 97 percent of the catch being consumed domestically. Of this amount, approximately 30 percent is harvested in Alaska waters (Pacific Rim Fisheries Program n.d.). Dungeness crabs reach maturity at 3 years. At 4 to 5 years of age, Dungeness crabs can reach more than 6.5 inches in shell width and weigh 2 to 3 pounds. Dungeness crab harvest tonnage and ex-vessel value for 1995 through 2000 is presented in Table 3.4-28. The ex-vessel value has varied over that period, with a high of $9.4 million in 1995 and a low of $4.3 million in 2000.

Korean hair crab is found primarily in the nearshore waters surrounding the Pribilof Islands in the middle of the EBS. The species has been used to support an experimental fishery, in which crabs were shipped live to Japanese markets. The hair crab catches have been steadily declining, which reflects both a diminished resource and poor market conditions. The available data concerning Korean hair crab harvest from 1995 to 1999 is presented in Table 3.4-29. During that period, ex-vessel values declined from $5.2 million in 1995 to less than $1 million in 1999.

3.4.2.4 Herring Fisheries

3.4.2.4.1 Summary of Management Program

The herring fisheries occur within state waters and are, therefore, managed by the state of Alaska. ADF&G regulates and monitors the resource by 20 separate fisheries.

3.4.2.4.2 Description of Fisheries and Gears

Herring are harvested by using several different gear types, including floating gill nets, bottom set gill nets, and purse seines. These gear types are essentially similar to gear described for salmon fisheries in previous sections.

3.4.2.4.3 Geographic Distribution and Intensity of Fishing Effort

Herring fisheries occur in specific areas in the GOA and the EBS when the stocks come inshore to spawn. In the GOA, spawning concentrations occur mainly off southeastern Alaska, in Prince William Sound, around Kodiak Island, and in Cook Inlet. In the EBS, the centers of abundance are in northern Bristol Bay and Norton Sound. Although most herring are harvested in the sac-roe season in spring, fall seasons are also designated for food and bait harvesting.

In the EBS, catches peaked dramatically in 1970 at more than 108,000 mt and fell to 19,050 mt in 1977 (NOAA 1999). Since then, catches have risen slowly but steadily, reflecting better stock conditions. A portion of the EBS harvest is taken as bycatch in the groundfish fishery. Regulations now limit bycatch to about 1,000 mt. The GOA herring fisheries have a history of harvest, going back to the 1900s.

Catches peaked at over 108,000 mt in 1936. In recent years, catches have risen slowly from a low level of abundance in 1967. In more recent years, statewide herring harvests have averaged about 45,000 mt. The majority of the harvest was roe-bearing herring (about 90 percent) and the remainder was food-and-bait herring (about 10 percent). The herring roe-on-kelp harvest (about 150 mt) is minuscule in percentage terms.

From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes. The period since the mid-1970s seems to be one of low-to-moderate herring abundance. Abundance of the stocks depends mostly on highly variable year-class strengths. A strong 1988 year-class, which dominated the stock, declined rapidly in abundance and was replaced by another strong year-class – 1992. Table 3.4-30 provides catch information for herring in 1999.

Pacific herring bycatch limitations in the groundfish fisheries apply to trawl gear in the EBS. The PSC limit for trawl gear is determined each year when TAC specifications are reset, and it is set at 1 percent of the estimated EBS herring biomass, which is further apportioned by target fishery (50 CFR 679.21 (e)(1)(iv)). Should the PSC limit for a particular groundfish target be reached during the fishing year, the trawl fishery for that species is closed in the herring savings areas (50 CFR 679.21 (e)(7)(v)).

3.4.2.4.4 Existing Socioeconomic Conditions

Unless otherwise noted, the material presented below is derived from the *Overview of Alaska's Herring Fisheries* (ADF&G 2002a). Herring and herring roe have been exploited as a food source in Alaska since prehistoric times. Traditional dried herring remains a food staple in EBS villages near Nelson Island. Southeast Alaska Natives continue to harvest eggs deposited by spawning herring on hemlock boughs placed in the water. Early European settlers salted herring in the manner used to preserve North Sea herring. Salted and pickled herring production peaked after World War I with an annual harvest of about 14,000 tons. In the 1920s, herring became increasingly valued for oil and meal. Plants to reduce herring to meal and oil proliferated along the GOA coast. In the 1920s and 1930s, harvests exceeded 125,000 tons. Such catch levels were unsustainable and may have caused stocks and fisheries to decline. In the 1950s, competition by cheaper Peruvian anchoveta severely affected the oil and meat markets. The last remaining Alaska reduction plant closed in 1966.

Foreign exploitation of the EBS fishery dominated the Alaska herring industry in the 1960s and 1970s, driven by the decline in the Japanese herring fishery. Inshore domestic fisheries began to fully utilize EBS herring subsequent to 1980; foreign harvests were eliminated under provisions of the MFCMA. The lucrative market for herring roe and eggs on kelp, still dependent upon Japanese demand, has promoted development of the state's roe herring fisheries and remains its principal use. Sac roe fisheries harvest herring immediately prior to spawning using purse seine or gill nets. Most of the catch is ultimately transferred in the round to Japanese freighters. In Japan, where all the value-added occurs, the roe is removed from the female carcasses, which, together with their male counterparts, are ground into meal. The roe is salted and packaged as a product that sells for more than $100/lb.

Herring eggs are also harvested in the spawn-on-kelp (or hemlock bows) fishery, in which the eggs are naturally deposited on vegetation. Eggs are collected from wild kelp and *Fucus* in Prince William Sound and Togiak. Eggs are harvested from impounded herring at facilities in Prince William Sound, Hoonah Sound, and at Craig.

Herring has been harvested commercially as bait since around 1900. Typically this catch averaged 2,000 to 3,000 tons per year. The development of extensive Alaskan crab fisheries beginning in the 1970s increased the demand for herring bait. In recent years, bait harvests have averaged around 8,000 tons.

Two distinct herring populations are exploited commercially off the coast of Alaska. GOA herring are genetically distinct from EBS herring. The former are non-migratory, moving less than 100 miles between spawning, feeding, and wintering grounds. EBS herring are much larger, longer lived, and often travel more than 1,000 miles during their annual cycle. While sac roe fisheries occur all along the Alaska coast from Norton Sound south, the two fisheries in Sitka Sound and Bristol Bay have, at least in recent years, accounted for more than 75 percent of the tonnage and ex-vessel value of the harvest (ADF&G 2000c, 2001, 2002b). The locations of the different fisheries are shown on Figure 3.4-40.

Most Alaska herring fisheries are regulated as geographically distinct spawning aggregations defined by regulation. These aggregations may occur in areas as small as several miles of beach, to areas as large as the entire Prince William Sound. The Alaska BOF has established a maximum exploitation rate of 20 percent of the spawning population of an aggregate population. Exploitation of a particular aggregate is terminated when this threshold is reached. Lower exploitation rates are imposed when stocks decline to near threshold levels. Fisheries are canceled in years when stock size is below threshold.

Following the onset of sac roe herring harvesting in the 1960s, the annual harvest increased rapidly. By 1980, the annual harvest reached 40,000 tons (ADF&G 2001; see Figure 3.4-41). Between that time and 1999, the harvest exceeded 40,000 tons every year but 1990. Since 1999, however, the harvest has been below the 40,000 ton level.

Table 3.4-31 presents the harvest and ex-vessel value of the statewide sac roe herring catch from 2000 to 2002. As can be seen, the data are incomplete and do not supply enough information to compare harvest and ex-vessel values among fisheries and years. Table 3.4-32 provides more complete harvest data for the EBS fisheries from 1980 through 2002. Ex-vessel values are not provided, however.

3.4.2.5 State-managed Salmon Fisheries

3.4.2.5.1 Summary of the Management Program

The following was adapted from Kruse et al. (2000). In Alaska, all salmon fisheries operate under a limited entry system. Limited entry is a state program developed to limit the units of gear used in order to maintain the resource and/or economic health of the fishery. It became apparent in the early 1970s that salmon fisheries were in need of additional help. Management tools such as shortened seasons and catch limits were ineffectual in providing sufficient conservation to many stocks. As a result, these fisheries were placed under limitation, metering the number of permanent commercial fishing permits available for the fishery. Anyone wishing to enter a limited fishery must receive a permit via transfer from another fisherman. Anyone already participating in the fishery when the fishery became limited could apply for a permanent permit during a one-time-only application period. Approximately 12,000 salmon permits were issued initially, although not all of those permits are active today.

Another tool developed in the early 1970s was salmon enhancement. Salmon hatcheries have existed in Alaska as far back as the late 1800s. Success of these early facilities was limited. The federal government started several research stations, as well as territorial hatcheries in the 1930s and 1950s. Enhancement planning in the early to mid-1970s called for significant capital construction under a newly formed division within ADF&G. At its peak, the department operated 20 hatcheries statewide (including two streamside incubation facilities, rather than permanent hatchery structures). In 1999, Alaska hatchery operators collected over 1.7 billion salmon eggs. In addition, 1.1 billion fish were released, and more than 41 million fish were harvested in common property fisheries as a result of the ocean ranching program. This harvest represents 22 percent of the commercial common property harvest of 215 million fish in 1999.

Habitat protection and restoration also became important tools in rebuilding salmon stocks in Alaska. Although most of Alaska's habitat remains very pristine and quite productive, the importance of habitat interaction became very apparent in the overall rebuilding process over the past several decades, as well as maintenance of the health of those stocks, once rebuilt.

For all salmon species, fishery performance analysis—the analysis of catch rates over a series of years—plays a part in fishery management as a check on the escapement monitoring, or even as the key indicator for hard-to-monitor species like coho salmon.

Escapement goals are thought to be one of the keys to the success of salmon fishery management. The criteria that the department uses to determine escapement goals are outlined in the escapement goal policy. ADF&G determines biological escapement goals as the range of escapement levels that provides the potential for maximum sustained yields. ADF&G seeks to establish and manage salmon fisheries for biological escapement goals, unless otherwise directed by the BOF. The status of salmon stocks is determined based on average levels of escapement relative to established escapement goals.

Another key to the success of this kind of fishery management is flexible, dynamic local control. Local fisheries managers are given virtual autonomy to open and close fisheries on very short notice, based on assessment information that has been collected in the previous several hours. Local management teams usually have years of experience with local fishing conditions, weather, and fish behavior. They can respond very quickly to allow additional harvest opportunities if fish runs suddenly build, and managers can quickly restrict harvests to ensure escapement goals if runs appear to be weaker than expected.

A third key to the success of this kind of management is that local managers are distanced from decisions about the allocation of harvest among competing groups of fishermen. This shields managers from politics and allows them to concentrate on managing fisheries according to prescribed management plans.

The BOF is a separate, explicitly political body, that addresses allocation issues. The BOF develops management plans, which direct the local managers on fishery management objectives, including the allocation of harvests among user groups. The plans are developed in open, public meetings after considering public testimony and advice from various scientists, advisors, and interest groups. Because of the magnitude of commercial fisheries for salmon, state biologists collect extensive information and statistics for management decisions. Alaska also has very important, but often less closely monitored, sport and subsistence fisheries for salmon, char, and trout. Many Alaska Native populations still depend heavily on subsistence-caught salmon for food and cultural purposes. State law gives top priority to the subsistence use of fish resources, which is reflected in BOF-approved FMPs. Around Alaska, there are a number of exceptions to the rule of fixed escapement goals. Along the South Alaska Peninsula in June, an important fishery for sockeye salmon is regulated by restricting the harvest to a fraction of a preseason forecast for Bristol Bay sockeye salmon. The troll fishery for chinook salmon in Southeast Alaska is controlled by a complicated series of caps based on the abundance of a suite of large stocks. Some fisheries in western Alaska are regulated by restriction of fishing times. Harvests in sport fisheries are usually controlled by bag limits and restrictions on when fishing can take place. The harvest rate is usually low in fisheries that are not managed for fixed escapement goals (usually far below 10 percent), and the fisheries are monitored by analysis of fishery performance data.

3.4.2.5.2 Description of the Fisheries and Gear

3.4.2.5.2.1 Alaska Salmon Set Gill Net Fishery

Description of gear used: This fishery is prosecuted with anchored gill nets. The gill nets are hung from the set line with corks on the top and a leadline on the bottom. Maximum gill net size is limited by state regulations, which vary by region. Gill nets for the set gill net fishery must be made of multifilament line. A mesh lead may be used in the intertidal area to guide salmon during the high tide periods.

Description of fishery operations: Most set gill nets are anchored on the beach, and the offshore end is secured to anchors and buoys. Some nets have what is called a lead, which is usually very large mesh seine webbing at the ends of the set gill net to channel the fish toward the net. Some nets are not anchored to the shoreline, but are held stationary with anchors on each end of the net. Set gill nets can be simply set in a straight line, or set to have a v-shaped hook at the end. Salmon are caught in the nets by their gills. Fishermen may use small skiffs to tend the nets and pick the salmon, or the nets can be accessed by motor vehicles and picked at low tide in some areas (e.g., Bristol Bay). In some areas, the entire net contacts the substrate at low tide. In other locations, only the leader and the shallower portion of the gill net would contact the bottom. Set gill nets are used in most areas of the state.

3.4.2.5.2.2 Alaska Salmon Drift Gill Net Fishery

Description of gear used: Drift gill nets (Figure 3.4-42) function by catching the fish by the gill cover and preventing escape. Gill nets are hung with corks on the top side and a leadline along the bottom. Maximum drift gill net length and depth are limited by state regulations, which vary by region. Most gill nets are 200 fathoms long and 2 to 7 fathoms deep. Each end of the gill net is marked with a buoy, but is not anchored to the bottom. Webbing for gill nets varies by region; however, monofilament nets are not allowed. Mesh size varies with targeted species.

Description of fishery operations: Gill nets are set where there are signs of a salmon, such as 'jumpers.' Most gill net fisheries occur in marine waters. To set the net, one end of the net and buoy is put into the water, and the remaining net is pulled off the vessel as it moves away. Sets are commonly made in a straight line, perpendicular to the shoreline. The net is pulled back on board with the aid of a hydraulic reel mounted either on the stern or the bow of the vessel. Salmon that try to swim through the net are caught by their gills. In most areas, drift gill nets do not contact the bottom. Drift gill nets are used in most areas of the state.

3.4.2.5.2.3 Alaska Salmon Seine Fishery

Description of gear used: This fishery is primarily prosecuted with purse seines (Figure 3.4-43). The length and depth of seines can vary by region of the state. Purse seines are nets with corks on the top and a leadline along the bottom. The nets can be closed at the bottom by means of a free running line through rings attached to the leadline or to a ribline, which runs parallel to the leadline, but is located in the body of the net above the leadline. Maximum seine size is limited by state regulations, which vary by region. The largest of these nets is 250 fathoms in length, and the smallest is 100 fathoms. Depth also varies regionally, with most salmon seines being about 10 fathoms in depth. Mesh size may vary throughout the net, with 3.5- and 4-inch mesh being most common. Twine size is generally #21, but may be as large as #42 in the meshes closer to the leadline.

A beach seine is a net that is set from and returned to the beach. This seine does not have a purse string, but is dragged along the bottom to pull in the fish.

Description of fishery operations: Sets are generally made where there are signs of salmon such as jumpers. At other times, sets may be made based on prior experience of the captain or crew. When setting a purse seine, one end of the net is held by the seine skiff, and the seiner moves in the opposite direction, launching the net. The skiff continues to pull until all of the net is off the deck. With the net hanging in the water like a curtain, the seine skiff and seine vessel meet and join both ends of the net to the seiner. Hauling in the bottom line, or purse line, closes off the bottom of the net, entrapping the fish. Sets may be circular, or they can be adjusted around depth contours to avoid hang ups, to prevent being pushed by current and waves, or for other reasons. Following pursing up the net, the seine corks, webbing, and leadline are pulled back onto the deck through a power block that is suspended from a boom off the boat's mast. Once most of the net has been retrieved, the fish are lifted in the purse, which remains in the water. The fish are spilled onto the deck and sorted into compartments below decks.

The beach seine must be set from, and hauled to, the beach, or to a vessel anchored to a beach. One end of the beach seine must remain on the beach above the water at all times during the set. There is no purse in a beach seine. The fish are contained by the walls of the net and the substratum.

In shallow water seine fisheries, there is likely to be interaction between seines and bottom habitat. The nets are set as close to shore as possible and configured in a "J" out from the shore. The level of interaction varies by operation and bottom type.

3.4.2.5.2.4 Alaska Salmon Rod and Reel Fishery

Description of gear used: The rod and reel fishery uses spinning, casting, trolling, and flyfishing gear. Hook sizes can vary depending upon target species, gear type, and fishing method (bait, fly, or other artificial). When river fishing for salmon, salmon roe may be used as bait if regulations permit. Lead sinkers (or downriggers when in the ocean) may be attached to get the hooks to the depths where the salmon occur. Snagging is allowed in some tidewater areas. Snagging gear is generally a weighted treble hook. This practice can have potential effects on the bottom habitat (leaving lead on the bottom, moving wood on the bottom).

Description of fishery operations: River fishing is done by standing on banks, wading from shore, and from boats. Ocean fishing is done from shore and from boats. In most river fishing, the line is cast slightly upstream and allowed to sink and drift through areas holding salmon. These casts are repeated until a fish takes the hook or the angler changes location. In ocean fishing, baited hooks are trolled at slow speeds behind the recreational boats in areas where salmon may be feeding or migrating. When a fish is hooked, the angler 'plays' the fish, reeling in the line when possible. Landed fish are either released or retained.

Sport recreational, sport commercial, and subsistence/personal use fishing all may employ rod and reel. Locations of operations vary.

3.4.2.5.2.5 Alaska Salmon Fish Wheel Fishery (Commercial and Subsistence)

Description of gear used: This fishery is prosecuted in the Yukon, Copper, and Kuskokwim rivers with stationary fish wheels. The Yukon has commercial fish wheels. Subsistence fishwheels occur on the Yukon, the Kuskokwim, and Copper rivers. A fish wheel is constructed of two lift nets made of 2-inch galvanized screening attached to a circular frame operated by the river current. Paddle boards catch the current and create the movement of the fish wheel nets. These boards are adjusted to the speed of the river current so that maximum catching efficiency is achieved. The wheel is mounted on a floating raft. The raft is anchored to a tree or rock upriver and pushed out into the current.

Description of fishery operations: As a fish swims near the wheel, it is scooped up in the net, slides toward the axle as the wheel turns, and is deposited in a holding box. Fishermen generally unload the boxes several times per day.

3.4.2.5.2.6 Alaska Salmon Subsistence/Personal Use Fishery

Description of Gear Used: Drift gill nets, set gill nets, dip nets, beach seines, rod and reel, fish wheels, and trolling are all used in the prosecution of subsistence/personal use fisheries for salmon in Alaska. Gear size limitations may pertain in these fisheries.

Description of Fishery Operations: The relative effect of subsistence/personal use fishing on fish populations varies by region within the state.

3.4.2.5.3 Geographic Distribution and Intensity of Effort

The following was adapted from Kruse et al. (2000). Fishing seasons for salmon in Alaska depend on species and particular run timing. Generally, chinook salmon are caught in May and June, although a Southeast Alaska winter troll fishery operates from October 11 through April 14. Sockeye salmon are generally harvested from mid-June to mid-July, but the earliest commercial salmon fishery occurs on the Copper River in mid-May. Coho salmon fisheries typically occur from late July to mid-September, but some limited effort may extend through early October. Pink salmon are harvested from late July to late August. Summer chum salmon runs are harvested from June through early August, and fall chum runs are harvested from early August through mid-September. Taking all Alaskan commercial salmon fisheries together, the largest portion of the statewide catch occurs during August (over 50 percent) when pink salmon are abundant, followed by catches in July (38 percent), which has large numbers of sockeye salmon.

Salmon catches in Prince William Sound, Kodiak, and South and North Alaska Peninsula areas are dominated by landings in July and August. Harvests in July dominate the CI and Bristol Bay areas, whereas the landings in the Chignik area are more evenly dispersed from June through August.

The spatial distribution of sockeye salmon harvests is highly aggregated in terminal areas close to natal lake and river systems. For the coastal purse seine fisheries targeting pink and chum salmon, the spatial distribution of the harvest tends to be in the migratory corridor, near terminal areas, and in areas near hatcheries. The heaviest catches in Prince William Sound come from statistical areas in the northern and southwestern portions of the management area. In the CI, most catches occur in the upper portion of the inlet, whereas catches along the western side of Kodiak Island dominate the salmon catches in that management area. In the Chignik area, statistical areas in the bay and south of the bay dominate the catch, and in the South Alaska Peninsula area, the heaviest catches come from the Shumagin Islands and statistical areas to the southwest. In the North Alaska Peninsula, the catches are dispersed throughout the area. Harvests from Bristol Bay are tightly aggregated in association with principal river systems flowing into the bay.

The location and habitat types where the fisheries occur may differ greatly by gear type. Most set net sites are attached to the shore in generally shallow habitat areas with variable currents and bottom substrate. Drift gill nets are set over any bottom type, wherever salmon are migrating in the ocean, inlet, and bays. For the most part, gill nets are set in nearshore areas and are fished in the upper water column. Drift gill nets are not generally designed for bottom interactions, but occasionally contact occurs.

Seine sets can occur over any bottom habitat type and at almost any depths. Most commonly, salmon seiners work in coastal waters. In most situations, the netting does not contact the bottom, with the exception of beach seine contact points with the beach.

Rod and reel fishing occurs in a variety of habitats, including nearshore and offshore marine areas, rivers, and lakes. Mouths of rivers, as well as upstream areas on rivers and lakes, receive the most fishing pressure. In river fishing, salmon are generally caught in areas with moderate flow near river banks. The bottom type is generally cobble and is rocky due to the current. In ocean fishing, salmon are caught over a wide variety of bottom types and depths, and fishing can occur in offshore areas.

In the commercial and subsistence fish wheel fishery, fish wheels are located in areas of the river, close to the bank, where the salmon are migrating. In all situations, no part of the fish wheel contacts the river bottom. In addition, nearshore, shoreside, river, and lake habitat areas may be involved in subsistence and personal use salmon dipnet fishing.

3.4.2.5.4 Existing Socioeconomic Conditions

The narrative presented below, unless otherwise noted, is derived from the *State Managed Species, Major Commercial Species* summary, prepared by the Pacific Rim Fisheries (n.d.). There are five species of salmon inhabiting Alaska waters. All are fully utilized from a commercial harvest standpoint.

Chinook salmon are the largest of the Pacific salmon. A 126-pound chinook was caught by a trap in 1949, and a 97-pound chinook was caught by a sports fisherman in 1986. Commercially caught fish average 18 to 20 pounds, but often exceed 30 pounds. Chinook salmon are the first species to begin spawning migration, and they have two runs annually in some rivers. Commercial chinook fishing is concentrated in the Southeast Region and in Prince William Sound. In western Alaska, chinook salmon are more frequently caught as part of subsistence fishing.

Sockeye salmon are the secondmost abundant salmon harvested. The species generally accounts for 30 percent of the harvest by weight. Sockeye are the most valuable of the species, however, accounting for 60 to 70 percent of the annual ex-vessel value. The Bristol Bay sockeye salmon fishery is the most valuable in the world, frequently yielding an ex-vessel value of $300 to $400 million annually. The sockeye harvest is concentrated in Bristol Bay, but also constitutes a considerable (and often the most valuable) component of harvests in the South-central and Southeast regions.

Coho salmon are the Alaska species most similar to their Atlantic counterpart, and they are favored for their mild-flavored flesh. This trait results in an above-average, ex-vessel value. Cohos constitute approximately 4 percent of the commercial catch. They are caught in nearly all areas, although the harvest is concentrated in the southeast region.

The most abundant salmon species in Alaska waters is the pink salmon. This species accounts for 50 to 60 percent of the total harvest by weight. The harvest occurs in the Southeast and South-central regions and Kodiak Island. In Prince William Sound, a substantial portion of the pink salmon harvest is generated by hatcheries.

Chum salmon typically account for 15 to 30 percent of the annual salmon harvest by weight. Mature chums weigh between 7 to 18 pounds. The chum harvest is concentrated in the Southeast Region, with a substantial portion of the harvest derived from hatcheries.

As is to be expected, given the importance of salmon in the overall Alaska state-managed fishery, there are good statistical data concerning the salmon harvest. Tables 3.4-33 and 3.4-34 summarize the commercial salmon harvest from 1970 to 1989 and 1990 to 2002, respectively. Total salmon caught was highest in 1995 at 217,795,000 salmon. Total weight caught was highest in 1995 and 1996 at 907,780,000 pounds each year. Data on ex-vessel value are available only for 1994 through 2002 and indicate that the highest ex-vessel value of the period was reached in 1994, at $489.1 million. The lowest ex-vessel value of the period occurred in 2002, at $140.6 million.

3.4.3 Effects of Fishing Activities on Fish Habitat

This section reviews information available from studies relevant to the effects of Alaska groundfish fishing gear on EFH. It also provides more specific descriptions of the gear and methods used in each fishery. Only a few studies have been completed on the habitat effects of Alaska fishing gear, thus requiring extensive consideration of studies from other regions. This process required determining which studies are most pertinent to the gear and habitats of the Alaska region and, thus, will focus on a smaller group of studies than summarized in recent comprehensive reviews of international literature (Johnson 2002, NRC 2002). The research summaries below are organized by gear type and are preceded by general descriptions of the fishing gear used in Alaska groundfish fisheries.

Numerical results from some of these studies were used to generate input parameters for a model to examine such effects (Appendix B). The model, selection of input values, and results are all described in Appendix B.

3.4.3.1 Fishing Gear Used in Alaska Groundfish Fisheries

There are four main classes of fishing gear used in the groundfish fisheries affected by the proposed alternatives: otter trawls, scallop dredges, longlines, and pots. Each of these gear types are composed of several components whose characteristics will affect their actions on the benthic environment and, hence, their effects and the amount of habitat encountered. Effects will also depend on properties of the substrate and organisms. Because there have been no comprehensive, systematic surveys of this gear, this information is based on the knowledge of NMFS gear researchers and related information available to them.

3.4.3.1.1 Non-pelagic Otter Trawls

Otter trawls (Figure 3.4-2) are conical nets that are pulled through the water, gathering fish into the open forward end and retaining them in a restricted bag (codend) at the back end. This type of trawl has four main components that may contact the seabed: doors, sweeps, footrope, and netting.

Doors are flattened metal structures that ride vertically in the water and use the force of their motion through the water to spread the net horizontally. Some bottom trawl doors also use contact with the seafloor to augment this hydrodynamic spreading force. The weight of the doors (and some hydrodynamic forces) overcomes the upward pull of the towing cables to force the net down into the water.

Sweeps (as the term is used here; nomenclature varies between regions and individuals) are steel cables that connect the doors to the trawl net. Fiber and combination fiber/steel cables are also used. On bottom trawls, sweeps are commonly in contact with the seafloor and often have protective disks strung on them (more than 7 cm in diameter). The sweeps pass over the bottom at a narrow angle (i.e., 15º to 20º) from the direction of travel and herd near-bottom fish toward the trawl net.

The footrope consists of cable or chain connected along the bottom edge of the trawl net and is designed to contact the seafloor on bottom trawls. A 1996 survey of footrope types used off Alaska (168 observers delivered and returned forms from 95 vessels; Rose, C., NMFS, unpublished data) indicated that all vessels used large-diameter (averaging 39 to 47 cm by fishery) cones, spheres, or disks (i.e., bobbins). These bobbins are usually made of rubber, strung over the entire length of the footrope. Large-diameter bobbins are separated by sections of small-diameter disks, creating openings under the footrope that are an average of 13 cm in height and average two-thirds of the footrope in length. Elevating most of the footrope above the seabed reduces damage to netting and bycatch of crabs and other invertebrates. During fishing, the footrope is shaped like a horizontally spread "U" with the opening forward. Bobbins are nearly always used on the sides of the U (wings). In the center section, "tire gear" is used for cod, rockfish, and Dover and rex sole, as reported in all six reports from the Atka mackerel fishery and about half of the reports from the GOA fisheries. This gear consists of vehicle tires or sections of tires linked side-by-side to form a continuous cylinder (averaging 68 cm in diameter). Tire gear and other large-diameter bobbins are very effective at protecting the netting and making it possible to fish in areas with hard and uneven substrates.

The netting is the most easily damaged component of bottom trawls; hence, trawls are designed to prevent the netting from contacting the seafloor. Bobbin or tire footropes raise the netting so that only particularly prominent seafloor features should touch the netting. If the codend contained enough fish sufficiently heavier than water (flatfish) or rocks, pulling it down to the sea floor, the bottom of the codend would drag across the sea floor. Because codends have to be pulled up the vessel's stern ramp, they are equipped with ropes that limit their diameter to less than 8 feet, which also limits the amount of bottom affected by a dragging codend. Chafing gear is also installed on the underside of the codend to prevent damage to the net during towing, which probably also reduces the amount of interaction between habitat and the web of the trawl.

An important aspect of gear design, when considering bottom habitat effects, is the proportion of the trawl contact footprint that is made by each of the components. Trawl doors used in Alaska are typically less than 3 m along the edge that contacts the seafloor; because they are fished at an angle to their direction of movement, the doors will affect a path narrower than 3 m. The length of the sweeps will vary with target species, substrate, and individual/operator preference. A large vessel targeting flatfish on a smooth bottom may use 350 m of sweeps on each side, while a small rockfish trawler on rough bottom may only use 30 m. Adjusting for the angle of the sweeps, the sweep path may vary from 10 to 100 m on either side of the net. Thus, the area covered by the sweeps can vary significantly. The width of the trawl net itself will depend on how large a trawl the vessel can pull and whether a high opening or a wide, low trawl is selected. An approximate range would be from 12 to 30 m wide. Thus, most of the trawl's footprint results from the sweeps, followed by the footrope, with a relatively small area contacted by the doors.

3.4.3.1.2 Pelagic Trawls

Pelagic trawls (Figure 3.4-1) are special types of otter trawls that are fished entirely off the seabed. These trawls are typically much larger than bottom otter trawls, but the leading parts of the net are constructed of large meshes (more than1 m) for herding pelagic species into the trawl. The very large mesh openings greatly reduce hydrodynamic drag, so vessels can fish pelagic trawls that are much taller and wider than any bottom trawls they may use. These large meshes are required by law to allow for the escape of bycatch species that are not herded by these large meshes as easily as pollock, including halibut, sole, and crabs. Walleye pollock in the BSAI are caught exclusively by pelagic trawls, since non-pelagic trawling for pollock is prohibited. Pelagic trawls dominate the GOA pollock fishery and are sometimes used in rockfish fisheries. Seafloor contact is discouraged by prohibiting devices that protect trawl footropes. In the BSAI, vessels fishing for pollock are also limited by a performance standard prohibiting vessels from having more than 20 crab on board, which would be an indication of bottom trawling. The resulting danger of trawl damage is likely to be effective in preventing on-bottom trawling with pelagic trawl gear in areas of rough, hard, or complex substrates, but not necessarily in areas where significant obstructions are unlikely. Anecdotal evidence indicates that pelagic trawls are frequently fished on the bottom in areas with smooth floors. An indication of the distribution of such substrates in the EBS is that NMFS surveys the entire EBS shelf with a trawl whose footrope is as vulnerable as those of pelagic trawls; however, NMFS uses bobbin-protected footropes in the GOA and Aleutians because of the frequency of rough substrates.

3.4.3.1.3 Scallop Dredges

The Alaska weathervane scallop fishery is pursued using a standard "New Bedford style" scallop dredge (Figure 3.4-35) (Posgay 1957, von Brandt 1984, Smolowitz 1998, NREFHSC 2002, Barnhart 2003, Figure 1). These dredges are heavy-framed devices with an attached holding bag, and they are towed along the surface of the seabed. The upper and forward part of the rectangular frame, or bail, is attached to the towing bar. The fixed opening in the frame is low in height relative to its width. Steel dredge "shoes" are welded onto both lower corners of the cutting bar, which is located at the bottom of the aft part of the frame. The dredge shoes bear most of the weight and act as "sled runners," permitting the dredge to move easily along the substrate. Regulation requires that the trailing ring bag, which retains the catch, consists of 4-inch (inside-diameter) steel rings connected with steel links to allow undersized scallops to escape. Rubber chaffing gear may be used to protect the steel links and the integrity of the ring bag. The top of the bag consists of 6-inch stretched mesh polypropylene netting, known as the "twine back." The mesh netting helps hold the bag open while it is dragged along the ocean floor. A club stick attached at the end of the bag helps maintain the shape of the bag and provides for an attachment point to dump the dredge contents on the deck. A sweep chain footrope sweeps back in an arc and is attached to the bottom of the mesh bag. The bottom of the bag was formerly attached directly to the lower bar of the frame, but most fishers believe that the dredge tends bottom better with the chain footrope rigging. Bottom tending is also assisted by a pressure plate, which is a length of steel attached along the width of the dredge and angled so that the water pressure passing over it creates a downward force on the dredge.

When fishing properly, the dredge shoes, ring bag, and club stick maintain contact with the seabed. The side of the bail is designed so that the angle between the bail and the mouth of the dredge may be changed to suit bottom conditions. When the bottom is soft, the dredge is rigged so that the cutting bar (or scraper blade) will tend to ride up over the bottom and there will be less tendency for the dredge to become clogged with mud. The turbulence created by the cutting bar stirs the substrate and kicks up scallops into the ring bag. On harder bottoms, a different setting is used so that the dredge will dig in somewhat and catch more of the scallops in its path. In Alaska fisheries, however, the cutting bar is fixed and rides above the surface of the substrate (Kandianis, T., April 30, 2003, Kodiak Fish Company, personal communication). Tickler chains that run from side to side between the frame and the ring bag may also be used in harder areas or as an alternate fishing method when catch rates are low (Kandianis, T., April 30, 2003, Kodiak Fish Company, personal communication). If used on softer bottoms, the tickler chains will also stir up the substrate and kick scallops into the twine top (Turk, T., May 1, 2003, NMFS Northwest Fisheries Science Center, personal communication). Rock chains that run from front to back are used in Atlantic scallop fisheries to keep larger rocks out of the ring bag, but are not used in Alaska.

Vessels used in the Alaska weathervane scallop fishery range in size from 58 to 124 feet LOA. The number of vessels is tightly limited, so vessels can be selective regarding the times and places that they fish. Those fishing inside the Cook Inlet Registration Area are limited to operating a single dredge not more than 6 feet wide. Vessels fishing in the remainder of the state are limited to operating no more than two scallop dredges at one time, and each scallop dredge is limited to a maximum width of 15 feet. Each dredge is attached to the boat by a single steel cable operated from a deck winch. On average, a 15-foot New Bedford dredge weighs approximately 2,600 pounds, and a 6-foot dredge weighs about 900 pounds.

3.4.3.1.4 Longlines

Demersal longlines (Figure 3.4-3) consist of two buoy systems that are situated on each end of a mainline to which leaders (gangions) and hooks are attached. The groundline (or mainline), usually made of sinking line (more dense than water), can be several miles in length and have several thousand baited hooks attached. Small weights may be attached to the groundline at intervals. Below each buoyed end is a weight or an anchor. A vessel may set a number of lines, depending on the area, fishery, and site. The principal components of the longline that can contact the seabed are the anchors or weights, the hooks, the gangions (lines connecting the hooks to the groundline), and the groundline (ICES 2000).

Longline gear in Alaska is fished on-bottom. In 1996, average mainline set length was 9 km for the sablefish fishery, 16 km for Pacific cod, and 7 km for Greenland halibut; average hook spacing was 1.2 m for the sablefish fishery, 1.4 m for Pacific cod, and 1.3 m for Greenland halibut. The gear is baited by hand or by machine, with smaller boats generally baiting by hand and larger boats generally baiting by machine. Circle hooks usually are used, except for modified J-hooks on some boats with machine baiters. The gear usually is deployed from the vessel stern with the vessel traveling at 5 to 7 knots. Some vessels attach weights at intervals along the longline, especially on rough or steep bottom, so that the longline stays in place and lays on-bottom.

3.4.3.1.5 Pots

Pots are baited enclosures (Figure 3.4-34), usually with one-way entrances, that retain entering fish and crab. Pots used in the Alaska cod fishery are generally modified from the designs developed for the crab fishery, with the one-way entrances modified to account for differences in crab and cod behavior. The most common design is a rectangular frame approximately 2 by 2 by 1 m made of welded steel rods with entrances on opposite walls. Because of solid steel construction, the pot weight (500 to 700 pounds) is not greatly reduced by immersion in water such that no additional anchors are required. Except in the Aleutians and certain months in the EBS, Alaska groundfish regulations require that each pot have its own buoyed line, so there are no underwater lines connecting adjacent pots (longlining). An exception to this is the deep-water brown king crab fishery in the Aleutian region, where the pots are longlined.

3.4.3.2 Effects of Fishing Gear on Benthic Habitats

Research conducted on effects of fishing gear on benthic habitats broadly recognizes several factors that influence the occurrence and degree of effect. Among these are (1) the intensity of fishing, (2) the frequency of fishing, (3) the class and specific characteristics of the fishing gear, (4) the environmental/ habitat characteristics, and (5) the level of naturally occurring disturbance. This section reviews worldwide literature on the habitat effects of fishing gear relevant to the groundfish fisheries of Alaska. Studies based on gear classes not used in Alaska fisheries, such as beam trawls and hydraulic dredges, were not directly evaluated. Studies of passive gears are extremely limited; therefore, all were reviewed.

3.4.3.2.1 Non-Pelagic Trawls

Information was collected for a range of studies of the effects of otter trawl fishing on benthic habitats (Table 3.4-35). Information on gear (diameter of largest footrope elements), fishing intensity, and habitat (substrates, depth, latitude, and region) was noted where available, as well as whether recovery was observed. The following paragraphs summarize conditions for Alaska fisheries, which were the basis for subjectively assigning the studies into broad classes of relevance.

As mentioned previously, Alaska trawl fisheries primarily use groundgear with large-diameter (average 39 to 47 cm) elements separated by small-diameter spacer sections, resulting in discontinuous contact across the footrope (tire gear being an exception). Studies with substantially smaller footropes may affect habitat differently (Wassenberg et al. 2002, Moran and Stephenson 2000, VanDolah et al. 1987) so this information must be used judiciously.

Alaska experiences lower overall fishing intensity relative to many of the areas where fishing effects research has been done (i.e., NW Atlantic and North Sea) (NRC 2002). Overall, the areas experiencing trawling intensities above one event per year in small (5 by 5 km) areas are less than 2 percent for the EBS, 3 percent for the Aleutians, and 2 percent for the GOA; In comparison, it is 56 percent for northeastern United States fisheries. A more detailed study of the distribution of effort intensities during recent years is being conducted at the AFSC. Estimated for each study summarized below are fishing intensities, in number of trawl contacts of studied locations (see Table 3.4-35).

While Alaska marine waters include a full range of substrates, the dominant bottom trawl fisheries target species that primarily occur over sand and gravel substrates, including yellowfin and rock soles (Smith and McConnaughey 1999, McConnaughey and Smith 2000) and cod. Studies on silt/clay environments are more relevant to the smaller fisheries for flathead, Dover and rex soles, and Alaska plaice. Studies of hard bottom, gravel, and boulder habitats are most applicable to the rockfish and Atka mackerel fisheries of the GOA and AI.

While fishing depths off of Alaska also range widely (10 to 1,000 m), most of the effort is concentrated in the 25 to 100 m range. Average fishing depth is deeper in the GOA than in the EBS, with more effort in the 100 to 200 m range. Alaska fisheries are conducted between latitude 51° and 61° N. Biotic habitat responses affecting recovery may be different in warmer climates.

Some of the studies contained information on the rate of recovery from fishing effects. The length of the recovery period observed is also included in Table 3.4-35.

Using these selection criteria, seven studies were selected as most relevant to Alaska groundfish fisheries, including three in Alaska and four from eastern Canada. These studies examined similar scale gear in a comparable environment. The six studies with the next level of similarity looked at somewhat different gear types or environments or, in the case of one Alaska study looking at crab injury rates, could only be related to more general effects on benthic habitat. The third class included many studies with very small or unknown footropes (shrimp or *Nephrops* trawls), many in silt/clay or very deep environments, and some in low latitude areas. Putting studies in this final class by no means indicates that they do not contain useful information, but rather that results should be interpreted with the noted differences in mind and that they may apply only to a small portion of the Alaska trawl effort, if at all.

Finally, several studies from Alaska were identified that have yet to be published, but for which field work has been completed. These will all be very relevant to this subject when their results become available.

3.4.3.2.1.1 Published Studies About Non-pelagic Trawl Effects

Based on the information available to date, the predominant direct effects caused by bottom trawling include smoothing of sediments, moving and turning of rocks and boulders, resuspension and mixing of sediments, removal of seagrasses, damage to corals, and damage or removal of epibenthic organisms (Auster et al. 1996, Heiftez 1997, Hutchings 1990, ICES 1973, Lindeboom and de Groot 1998, McConnaughey et al. 2000). Trawls affect the seafloor through contact of the doors and sweeps, footropes and footrope gear, and the net sweeping along the seafloor (Goudey and Loverich 1987). Trawl doors leave furrows in the sediments that vary in depth and width depending on the shoe size, door weight, and seabed composition. The footropes and net can disrupt benthic biota and dislodge rocks. Larger seafloor features or biota are more vulnerable to fishing contact, and, larger diameter, lighter footropes may reduce damage to some epifauna and infauna (Moran and Stephenson 2000).

McConnaughey et al. (2000) compared benthic megafauna from untrawled (UT) and heavily trawled (HT) areas straddling a closed area boundary in the eastern Bering Sea. The study site was relatively shallow (44 to 52 m depth) with sandy substrates and ubiquitous bottom ripples. A relatively short fishing history and extensive observer coverage provide a high level of certainty that the UT (control) stations inside the closed area have never been trawled. Multivariate and univariate statistical tests were used to evaluate population- and community-level effects of trawling. Statistical results were adjusted for multiple comparisons (Bonferoni corrections), limiting the overall level of false positives to the stated 10 percent level. The statistical power of tests was reported to assess the ability to detect actual differences due to trawling. Principal conclusions include the following:

1. The HT and UT areas are significantly different when all taxa are considered together.

2. Mean overall abundance of all 11 sedentary taxa represented in at least 25 percent of the 42 paired samples (e.g., anemones, ascidians, bryozoans, soft corals, sponges, whelk eggs), neptunid whelks, and empty shells was greater in UT areas; significant differences for one of the two participating vessels were detected in Actinaria, *Neptunea*, gastropod eggs, gastropod shells and Porifera.

3. Motile groups (i.e., crabs, sea stars, and whelks) and infaunal bivalves exhibited mixed responses, suggesting that life history considerations, such as habitat requirements and feeding modes, are important.

4. The overall diversity of sedentary taxa was significantly reduced in the HT area, related to single-species dominance by the sea star *Asterias amurensis* (-0.98 correlation between abundance and diversity in the heavily trawled area).

5. Sedentary taxa were significantly more patchy in HT areas.

6. Significant reductions in gastropod shells in the HT area may explain lower abundance of gastropod eggs, which use them for attachment, and hermit crabs, which use them for shelter.

A detailed review of the fishing history for the study area indicated the majority of trawling occurred 4, 5, and 8 years before the experiment was conducted in 1996, at intensities of approximately 4, 6, and 14 events per year. Only minimal fishing occurred after 1992 (less than 0.1 percent of the HT area was trawled). As such, significant differences were observed despite at least 4 years of recovery from high intensity fishing (1991-1992) and 8 years of recovery from very intensive fishing by foreign vessels (1988). This is particularly noteworthy, given that this is relatively high-energy habitat disturbed regularly by strong tidal flow and storm wave effects.

A follow-on analysis of these data compared mean individual size (kg) in the HT and UT areas for three sedentary (anemones, a cucumber, and a compound colonial tunicate), nine motile (five crab, two starfish, one snail, and one shrimp), and four infaunal clam taxa. The mean sizes of the whelk *Neptunea* (*P*=0.0001) and Actiniaria (*P*=0.002) were significantly smaller in the HT area. The mean size of *Crangon* (*P*=0.05) was also smaller in the HT area; however, the result was not statistically significant after a Bonferoni correction for multiple tests. Twelve additional taxa were also smaller in the HT area, albeit not significantly smaller. Observed HT-UT difference ranged from -4 percent (*Asterias amurensis*, *Hyas*, *Serripes*) to -68 percent (*Tellina*). Overall, the weighted-average effect for the infaunal group (-31.1 percent) exceeded that for the sedentary (-16.1 percent) and the motile (-9.1 percent, excluding *Paralithodes camtschaticus*) groups. The overall HT-UT difference in body size was statistically significant (*P*=0.0001).

The mean body size of red king crab (*P. camtschaticus*) was 23 percent greater in the HT area (*P*=0.17). This was the only exception to the overall pattern of smaller size in the HT area. An examination of carapace length (CL) frequencies indicated this mean effect was primarily due to the presence of fewer small crab rather than more large individuals in the HT area (*P*<0.0001, indicating that there is no difference in the two CL distributions).

Ten thousand eighteen within-year, within-taxon comparisons of mean body size were made using 1982 to 2001 NMFS trawl survey data collected in the CHPZ1 closed area. Overall, these comparisons indicate that natural variability of body size in untrawled areas is large relative to the observed HT-UT differences due to chronic bottom trawling. On average (weighted by the number of comparisons), spatial differences in body size exceeded the observed trawling effect in 91 percent of the comparisons involving sedentary taxa, 81 percent of those for motile taxa, and 22 percent of those for infauna. In the last case, the composite result is most applicable to the bivalve *Mactromeris* (*N*=563) because sample sizes for the other three taxa in this group (*N*=19 total) were quite low. Overall, 78 percent of all spatial differences in body size exceeded the HT-UT difference observed in the 16 benthic invertebrate taxa considered.

A study completed in the GOA (Freese et al. 1999) included trawling at eight sites (206 to 274 m) in August 1996, using a chartered trawler with a Nor'eastern bottom trawl, modified with 60 cm tires at the center of the footrope and fitted with 45 cm rockhopper discs and steel bobbins along the wings. From a research submersible, the researchers videotaped each trawl path along the 5 m section impacted by the tire gear and a nearby reference transect. The tapes were analyzed to obtain quantitative data. The researchers found that a single trawl pass affected the dominant features on the seafloor, displacing a significant number of boulders, removing or damaging large epifaunal invertebrates. A significantly lower density of undamaged sponges and anthozoans was found in the trawled transects than in the reference transects, and more of these organisms in the trawled transects were damaged. Approximately 70 percent of vase sponges, 55 percent of sea whips, more than 20 percent of brittle stars, and 13 percent of finger sponges were damaged. The study did not detect any change in the density of most motile invertebrates, or damage to them.

Epifaunal invertebrates such as these add structural complexity to the seabed, which may provide important cover and prey for demersal fishes. When boulders are displaced, they can still provide cover and surface area for the attachment of structural biota, but separating piles of boulders may alter the number and complexity of crevices. The researchers observed that various taxa, primarily rockfish (*Sebastes* spp.), use cobble-boulder and epifaunal invertebrates for cover, but it was not clear which habitat elements are required.

A subsequent survey at these sites 1 year later found the site relatively unchanged (Freese 2002). Sponge density was still higher outside the path of the tire gear than within it (3.5 /100 sq. m versus 2.76 in 1997 compared to 3.73 and 3.15, respectively, in 1996). The percent of vase sponges with damage had declined to 46.7 percent. These changes were reasonably interpreted to indicate that some of the damaged sponges had subsequently died. One of the areas with vase sponge had 9.9 percent of damaged sponges showing some necrosis, while the other two areas had none. The damaged sponges showed no signs of repair or regrowth.

Other studies have noted the preference of rockfish for different kinds of cover. Krieger (1993) noted that adult (total length more than 25 cm) Pacific ocean perch in Alaska are associated with pebble substrate on flat or low-relief bottom; juvenile Pacific ocean perch exhibit a preference for rugged areas containing cobble-boulder and epifaunal invertebrate cover; and shortraker rockfish strongly prefer rugged, high-profile habitat interspersed with boulders. Carlson and Straty (1981), Straty (1987), and Pearcy et al. (1989) also noted that juvenile rockfish exhibit a preference for high-relief habitat. Although reducing the number of sponges and associated invertebrate taxa reduces the shelter value of the invertebrate community, it is not known whether this change substantially affects associated fish.

In a fine sediment area of the Grand Banks of Newfoundland at 120- to 150-m water depth, which had been closed to fishing for 10 years, the physical effects of otter trawling (12 times a year for 3 years) over fine-to-medium grained sandy bottoms were examined. The features of the experimental trawl (i.e., 46-cm-diameter rockhopper gear (disks which do not roll) were consistent with trawl gears used in Alaska fisheries. Publications from this study have included a general summary (Gordon et al. 1998), habitat structure effects (Schwinghamer et al. 1996, 1998), and effects on megaepibenthos (Prena et al. 1999) and macrobenthos (Kenchington et al. 2001). Untrawled areas were hummocky, mottled, and had more flocculated organic matter while trawled areas were smoother and cleaner. Complexity of the sediment structure was reduced down to a depth of 4.5 cm. Trawl door tracks were visible for at least 10 weeks and in some cases for up to a year (Schwinghamer et al. 1998). Prena et al. (1999) found that immediate results of trawling included decreased biomass of sand dollars, brittle stars, soft corals, snow crabs, and sea urchins; an influx of scavenging crabs; and no effect on four species of molluscs. The experimental design did not allow recovery or long-term effects to be separated from immediate effects, because at trawled sites, epibenthic sampling always occurred after experimental trawling for that year had been completed. Kenchington et al. (2001) found significant infauna community changes due to trawling in only 1 of the 3 years. In that year, a number of polychaete species were reduced 39 to 61 percent after trawling. Proportions of damaged sand dollars and brittle stars did not change due to trawling. Tests for changes between years showed little indication of long-term effects, and when disturbance was evident, its nature closely resembled natural disturbance.

Gilkinson et al. (1998) pulled a model of trawl doors through a prepared test bed of sandy sediment with clams implanted in it to test the effect of trawl doors on substrate and infauna. They found that only 2 of 42 clams were significantly damaged by passage of a simulated trawl door, while most individuals were displaced along with the sediment out of the door's track. However, 64 percent of the displaced specimens were wholly or partially exposed afterward, leaving the clams more vulnerable to predation. The simulated door was similar to some used in Alaska fisheries.

Brylinsky et al. (1994) examined physical and biological effects of experimental fishing using a flounder trawl with 28-cm rubber rollers and no tickler chains in an intertidal estuary in the Bay of Fundy, Nova Scotia. Trawl doors made furrows that were visible for 2 to 7 months, and rollers compressed sediments. They sampled chlorophyll a (as an indicator of benthic diatoms) and abundance of nematodes within door furrows before and after trawling and found that both were reduced for approximately 1 month after trawling. Nematodes recovered fully after 4 to 6 weeks, and chlorophyll a concentrations increased fourfold after 80 days. Thus, the authors conclude that trawling caused no enduring effects on either benthic diatoms or macrobenthos. Authors stated that the quick recovery was expected since sediments in the area are commonly disturbed by storms and winter ice.

A single pass with a roller-rigged trawl in a hard-bottom sponge and coral community at 20 m in South Carolina damaged finger sponge, vase sponge, barrel sponges, whip coral, fan coral, stick coral, and stony tree coral and caused a decrease in density of barrel sponges (Van Dolah et al. 1987). Damage rates were 31.7 percent of sponges, 30.4 percent of hard corals, and 3.9 percent of octocorals. Impacts were not detectable 1 year later. The contrast between these results and those of Freese (2002) is likely due to environmental differences, such as warmer water and shallower depths.

Bergman and Santbrink (2000) estimated mortalities of North Sea megafauna and macrofauna from single passes of an otter trawl with 20-cm rollers and three types of beam trawls. At silty sites, direct mortality from otter trawling was lower than that for beam trawling. Differences at a single sandy site were less consistent. Estimated immediate mortalities by otter trawl ranged from 0 to 52 percent.

Sparks-McConkey and Watling (2001) tested for effects of trawling and recovery over a 16-month period on a silt/clay bottom in an enclosed bay with minimal scouring of the seabed by tides or storm events. Immediate post-trawl differences were detected for surface measurements of several sediment parameters (none at 5- to 7-cm depth), abundances of nearly all organisms and four community indices. Nearly all of these statistical differences were nonsignificant after 3 months. Differences remaining detectable after both 3 and 6 months included elevated abundances of a predatory nemertean and lower abundance of one polychaete.

Rose (1999) estimated the rates of injuries to hard-shelled red king crab passing under the center sections of three types of bottom trawl footropes commonly used in the bottom trawl fisheries of the EBS. Injury rates of 5, 7, and 10 percent were estimated for crabs passing under the three types of commercial footropes (Rose 1999).

In a study by Rumohr and Krost (1991), sedentary organisms living in the upper 5 cm of the seabed were found to be most vulnerable to damage from trawl doors. Thin-shelled, large bivalves and starfish had the highest proportion of injuries when collected by a dredge following a trawl door, while thick-shelled bivalves were less likely to be damaged.

Moran and Stephenson (2000) found that the light, medium-diameter (20-cm-diameter disks separated by 30- to 60-cm-long sections of 9-cm disks) footropes currently in use in northwest Australia result in less mortality (15.5 percent vs 89 percent documented by Sainsbury et al. in 1997) than heavy, small gear used in the past (continuous 15 cm disks). These tests were conducted at depths of 50 to 55 m with abundant attached macrobenthos. Similar bobbin and disk footropes used in most Alaska trawl fisheries average 39 to 47 cm in diameter, even larger (more than 2 times) than the less disruptive of the two Australian footropes.

Wassenberg et al. (2002) also studied the effects of trawls on sessile epifauna of the northwest Australia shelf. They used video to observe interactions between sponges and a trawl footrope (6- to 8-cm-diameter rubber disks with lead weights between). The leading edge of the netting was suspended 20 cm above the seafloor when the footrope (referred to as ‘ground-gear’) made direct contact. The size class and fate (pass under, caught on footrope, into net, smashed and in net, smashed and under) of each observed sponge were categorized. Overall, 13.8 percent of the sponges were removed, with likelihood varying between species and increasing with size. ‘Smashed’ sponges that passed under the net represented none of the small sponges, 3 percent of the medium sponges (301 to 500 cm high) and 20 percent of the large sponges.

Engel and Kvitek (1998) sampled lightly and heavily fished areas off central California. Sediments were similar between sites and consisted of gravel, sand, and silt-clay. Results indicated that heavily fished sites have more trawl tracks, consistant with their limited data on trawling distribution, more exposed sediment/shell fragments, fewer rocks and biogenic mounds, and less flocculent material. Invertebrate epifauna were more abundant in lightly trawled areas, and nematodes and polychaetes were more abundant in heavily trawled areas. The authors concluded that trawling reduces habitat complexity and biodiversity while increasing opportunistic infauna and prey important in the diet of some commercially important species.

Auster et al. (1996) observed rock and boulder fields on Jeffrey's Ledge in the Gulf of Maine, which had been vulnerable to trawling for at least 6 years due to modifications to fishing gear and practices. They documented that mobile fishing gear moved and rolled boulders and decreased the percent cover of sponges. Laboratory predation experiments (Lindholm et al. 1999) demonstrated that decreased habitat complexity led to increased predation on 0-year cod. Thus reduction in benthic epifauna by mobile fishing could have a major effect on cod and other fish populations.

At a 200-m, silty-clay environment in the eastern Mediterranean Sea, Smith et al. (2000) took video, sediment samples, and macrofauna samples before, during, and after an 8-month trawling season inside and outside of an established trawling lane. Otter trawl gear used by the commercial fishery was not specified. Video observations confirmed that trawl door disturbance was limited to the lane and persisted through the 4-month closed season. While organic carbon, chlorophyll, and phaetopigment differed between sites in the track, they did not differ from adjacent sites outside of the track, except in one case. There was no indication of deep sediment mixing. Macrofaunal communities varied between trawled and control stations, with diversity, abundance, and biomass higher in control stations and species evenness lower. Echinoderms and sipunculids were most affected by trawling.

Sanchez et al. (2000) observed the immediate effects of 7 and 14 passes of otter trawls along adjacent tracks and compared them to nearby, untrawled areas. The Mediterranean site had muddy sediments, was 30 to 40 m deep, and the ground contact components of the trawl were not specified. Sidescan records clearly showed the tracks of the trawl doors on the seafloor. Infaunal diversity and richness indices were not significantly affected by trawling. Nine of thirty-three taxa had higher abundances in the seven-trawl area than in the untrawled section due to a decrease in the untrawled site. Eleven of the thirty-three taxa were lower in the 14-trawl path than the reference area. Results suggested that sporadic trawling episodes in muddy habitats may cause relatively few changes in community composition.

Mayer et al. (1991) conducted experimental trawling in 20-m water depth over protected, fine grain, mud areas with a 60-foot (footrope length) otter trawl with chain groundgear. The 200-pound doors produced furrows several cm deep, and the chain and net produced very thin and inconsistent planing of surficial features. Organic matter profiles were unaffected by trawling, except for indications of export of a thin layer of surficial sediment. A similar experiment with a scallop drag produced much more significant effects (see below).

Frid et al. (1999) developed *a priori* predictions concerning the effects of fishing effort on species abundances. They tested those predictions using time series data from sand habitats in 55 m of water and silt/clay habitats in 80 m of water, off the coast of Northeast England. The *Nephrops* trawls used in this area have small diameter cable/chain footropes (Lindeboom and deGroot 1998). Taxa predicted to increase with fishing effort included errant or mobile polychaetes and asteroid echinoderms. Taxa predicted to decrease with fishing effort included sedentary or fragile taxa such as echinoid echinoderms, large bivalves, and sedentary polychaetes. Outside fishing grounds, those species predicted to increase and/or decrease with fishing remained constant. Inside heavily fished areas, those predicted to increase with fishing did, but those predicted to decline remained the same.

Ball et al. (2000) studied effects of trawling in 30- to 40-m water depth over mud areas of the Western Irish Sea using shipwrecks as controls for experimental trawling with a *Nephros* trawl with a tickler chain. Differences were detected between wreck sites and those exposed to fishing, which had fewer large-bodied fragile organisms, fewer species, more opportunists, and more small polychaetes in an altered but stable community. Interpretation of gear effects may have been confounded by effects of wrecks.

Tuck et al. (1998) studied a control site and an experimental site, sampling each before and after the experimental site was fished with rockhopper groundgear without an attached net. Both sites were on a silt/clay substrate in 35 to 40 fathoms of water in a sheltered Scottish loch that was not commercially trawled. Trawling lasted for 16 months (one tow per month) and sampling, including one pretrawling survey, continued for 18 months after trawling ceased. The trawl doors added furrows to a previously featureless seabed. Faint marks were still detectable 18 months after trawling. The trawled site had increased number of species and total individuals, with lower diversity and species evenness indices. Some community differences persisted after 18 months.

Drabsch et al. (2002) compared infauna communities in trawled sites and lightly trawled sites (trawling had not been reported in the last fishing season and very light trawling had been reported for the last 10 years) on sand and silt substrates in a bay in southern Australia. Trawling was done with a triple prawn trawl, a combination of three small trawls fished side-by-side. Non-overlapping, replicate cores were taken by divers at the same small-scale sites across time to avoid effects of spatial variability. Analysis of individual species patterns found no clear indications of short-term trawling effects. Sampling did not include door tracks.

Lindegarth et al. (2000) examined changes in macrofauna at three control and three trawled sites in a Swedish fjord before and during the last 4 months of a year of weekly trawling. Trawl gear was a shrimp trawl with a small (2-cm) footrope. Large temporal changes occurred at both control and trawled sites, resulting in no significant indication of trawl effects, though the centroids of trawled sites moved more than untrawled sites, and spatial and temporal variability was higher at trawled sites.

Thrush et al. (1998) tested hypotheses regarding trends in abundance of faunal groups and diversity for benthic fauna along a gradient of fishing effort by sampling 18 locations with similar habitats, but varying fishing effort, in the Hauraki Gulf, New Zealand. Typical doors used in that fishery weighed 480 kg, and footrope gear was 14- to 15-cm rubber or steel bobbins. However, interpretation of results in terms of trawl effects is confounded by the use of bottom seines in the area, at effort levels five times that of trawling, and the use of scallop dredges at most of the heavily fished sites. Sediments were described as 1 to 48 percent mud, and depths ranged from 17 to 35 m. After accounting for differences of location and sediment, 15 to 20 percent of the variability in macrofauna community composition was attributed to fishing. With less fishing effort, large epifauna, echinoderms, and the number of species and diversity of fauna were greater, and the number of deposit feeders and small opportunists were less. These results indicate broad-scale changes in benthic communities directly related to fishing with various mobile fishing gears and, because they were taken over a large sampling area, suggest ramifications for the entire ecosystem.

Gibbs et al. (1980) sampled macrobenthos before and after trawling with a shrimp trawl at three trawled and one control site in southeastern Australia and made underwater observations of trawl-seabed interaction. Classification analyses did not detect a trawling effect. Underwater observations indicated only light footrope contact.

Seamounts are also affected by trawl fishing. Corals from seamount slope areas comprised the largest bycatch from otter trawls with large bobbins along the ground rope fished in water depths of 662 to 1,524 m in tropical New Zealand. These coral patches may require over 100 years to recover, and many may be crushed or overturned without coming to the surface in a net (Probert et al. 1997). Koslow and Garrett-Holmes (1995) sampled benthic fauna over seamounts in Tasmania subject to varying levels of fishing effort. Substrates in heavily fished areas were predominantly bare rock or coral rubble and sand. Colonial corals and associated fauna were lacking. Species abundance and richness were also lower than in lightly fished areas. The authors attribute these differences to fishing effort and recommend permanently closed areas to protect fragile seamount ecosystems.

Destruction to coral-like bryozoan growths in Tasman Bay, New Zealand, coincident with trawling and dredging effort during the 1970s and 1980s, was attributed to chains, bobbins, sweep wires, and otter boards of the mobile fishing gear (Bradstock and Gordon 1983). These changes coincided with declines in juvenile trakihi and snapper abundance.

Brown (2003) studied both immediate and long-term/chronic effects of bottom trawling in shallow (16 to 30 m) area near Round Island in the EBS in summer 1999 and 2000. The seabed was primarily fine sand ripples 1 to 2 cm tall, spaced 10 cm apart, with low organic content. A statistical comparison of sediment profiles (top 5 cm) from an area closed to fishing for 7 to 8 years and an adjacent open area indicated that "vertical profiles of sedimentary organic matter, phytopigment content and grain size distribution were, for the most part, unchanged after chronic exposure to commercial flatfish trawling," although grain size was more variable in the closed area, and there was higher sedimentary chlorophyll a in the fished area. The magnitudes of calculated disturbances by winter waves and the trawl wake were comparable; however, it was noted that trawling occurs when sediment resuspension by natural processes is rare. Total density, biomass, diversity, and richness of the two infauna communities were compared in 1999 and again in 2000, with mixed results. Only species richness was consistently different (greater in the closed area) in both years, due to the absence of numerous rare taxa in the fished area. Qualitative analysis of video data indicated that epifaunal assemblages and demersal fish populations were similar in the closed and fished zones during both years.

Immediate effects of bottom trawling were studied in a before-and-after control-impact (BACI) experiment conducted in the Round Island closed area using fishing gear and a trawling intensity that is consistent with practices of the modern Bering Sea flatfish fleet (Brown 2003). The trawl footrope consisted of 36 cm disks spaced 23 to 38 cm apart while the bridles and sweeps were 274 m long and 13 cm in diameter. Ten non-overlapping tows over a 30-hour period crossed a 4 km^2 study area, such that 57 percent of the study area experienced direct contact with the trawl doors (5 percent), footrope (12.5 percent), and sweeps (43.5 percent). There were no statistical differences in any of the sediment parameter means and no statistically significant changes in the infauna community indices in the BACI experiment. Despite the intensive commercial fishing activity, video analysis of the sea floor failed to detect a change in abundance in any epifauna species, excepting the sea star *Asterias amurensis*, which had a significantly lower abundance afterwards. This difference may simply have been a shift towards a more clumped distribution, as groups of sea stars feeding on fish-processing waste were observed in the video.

In summary, only very limited chronic and immediate effects of bottom trawling were detected by these studies. Whereas these results are consistent with some reports for other shallow, sandy, and naturally disturbed areas, an unequivocal determination of negligible effect is not possible in this case. A number of experimental design (e.g., no spatial replication of the 4 km^2 study area and very limited control samples; more than 25 km separation between the fished and unfused areas) and sampling (only 2 of 11 grab samples after trawling were actually in the track of the trawl footrope; only nine total infauna stations in the fished and unfused areas) issues must also be considered.

3.4.3.2.1.2 Upcoming and Unpublished Studies

Several relevant studies have recently been done in Alaska waters for which field work has been completed, and analysis and reports are in process. These are expected to provide relevant and useful information on the effects of bottom trawling in this region. Comparative parameters of these studies are included in Table 3.4-35.

Infauna collections taken in 1997 from paired heavily fished and unfished sites in the EBS (experimental design similar to McConnaughey et al. 2000) have been processed and results are being analyzed (Lead Investigator—Bob McConnaughhey, AFSC, Seattle).

Another report provides a comparison of megafauna, biogenic structures and sediment characteristics within and outside of a zone closed to bottom trawling in the GOA (Lead Investigator—Bob Stone, AFSC Auke Bay Lab, Juneau).

A report provides a comparison of megafauna and sediment characteristics inside of experimentally trawled sites with untrawled control sites in an area of sea whip habitat near Kodiak Island (area closed to fishing). Stomach contents of resident fish species before and after trawling were also collected (Lead Investigator—Bob Stone, Auke Bay Lab, Juneau).

Laboratory observations of age-0 southern rock sole (*Lepidopsetta bilineata*) and Pacific halibut *(Hippoglossus stenolepis*) indicated a preference for substrates with 16 percent coverage of sponge over bare sand (Stoner and Titgen, In Press). Further testing indicated that predation on both species by 2-year-old halibut was less effective in the sponge habitat (Ryer et al., In Press).

A comparison of epifauna, infauna, and geological characteristics (including bedforms, sediment composition and chemistry) inside of experimentally trawled sites and untrawled control sites in outer Bristol Bay (area closed to fishing) (Lead Investigator—Bob McConnaughhey, AFSC, Seattle).

The AI area has not been studied specifically to determine effects of trawling, but Harold Zenger at the AFSC conducted a pilot study to examine the distribution and frequency of gorgonian and other corals in the Seguam Pass area of the AI. Historically, these corals were a major bycatch component of the Atka mackerel fishery in this area. The study goal was to examine coral distribution and appearance of corals in heavily trawled areas of Seguam Pass, as compared to less-trawled areas. Underwater video provided images of a number of distinct habitat types and associated fishes, invertebrates, sponges, and corals. Apparent trawl damage to hydrocorals was documented in an area known to be heavily fished in the past. Other areas showed no obvious signs of disturbance by fishing gear. The study documented interaction of rockfish and Atka mackerel with the habitat. The Seguam Pass area is composed of many habitat types ranging from large, barren sand dunes to dense sponge gardens associated with massive rock formations, as well as gradations of rock and faunal densities in between (Zenger, H., July 23, 2001, AFSC, personal communication).

3.4.3.2.1.3 Summary

In relating trawl research to the fisheries of Alaska, some conclusions can be drawn:

1. Bottom trawls commonly, but not always, cause detectable short-term changes in infauna, epifauna, megafauna and substrate in different habitat types.

2. In comparable environments, studies using larger diameter footropes with noncontinuous contact along their length, such as those used in Alaska, indicated less damage to upright, attached epifauna than those with smaller diameters and continuous contact (Moran and Stepheson 2000, VanDolah et al. 1987).

3. At higher trawling intensities, bottom trawling with large-diameter footropes can produce persistent changes in megafauna communities (McConnaughey et al. 2000) on naturally disturbed sandy substrates.

4. Even at relatively high intensities (12 tows per year), effects on infaunal communities may be ephemeral (Kenchington et al. 2001) on fine- to medium-grained sandy bottoms.

5. Large bodied, attached, and emergent epifauna are particularly vulnerable to trawl damage, even by a single pass at unimpacted sites (Collie et al. 2000, Van Dolah et al. 1987, Freese et al. 1999, Moran and Stepheson 2000), and effects can remain for at least a year in Alaska waters (Freese 2002). In Alaska, these fauna constitute the living substrate categories of HAPC.

6. Specific effects on EFH will depend on the fine-scale distribution and intensity of fishing effort relative to habitat distribution, levels of natural variability relative to fishing effects, and the nature of habitat dependencies of managed fish stocks. These are poorly known for Alaska EFH. Given discrete but overlapping spatial distributions of species reflecting different habitat preferences/requirements (e.g., McConnaughey and Smith 1999), differential responses to fishing gear effects are likely. In general, the ecological implications of reported changes due to bottom trawling are poorly known, particularly as they relate to sustainable fishery production and healthy ecosystem function.

3.4.3.2.2 Pelagic Trawl Gear

Pelagic trawls fished off-bottom have no known effect on benthic EFH. While some pelagic habitats may be very important to fish species, the chemical and hydrological features that make them important are not subject to change by the passage of fishing gear because of the continuous/fluid nature of the environment.

Indirect and anecdotal evidence suggests that, in some seasons and areas, pollock are distributed so close to the seabed that they could not be caught effectively without putting some parts of pelagic trawls in contact with the seafloor. Confirmation that such near-bottom distributions can be widespread includes the following: 1) in 5 out of 9 years that both acoustic and bottom trawl surveys were conducted in the EBS, the bottom trawl, which opens only 2 m high, detected more than 95 percent of the total biomass estimate for pollock more than 2 years old (2000 BSAI SAFE); and 2) the average acoustic measurements of pollock density from those surveys were five times higher half a meter above the bottom than at 2 to 4 m (Williamson, N., unpublished data, AFSC). As such, there is a strong incentive for fishing pelagic pollock trawls near/on the bottom.

The effects from pelagic gear being fished on the bottom have not been specifically studied, and there are some important differences from bottom trawls that must be considered in assessing likely habitat impacts. Pelagic trawls used off Alaska are generally designed to fish downward, with the entire net fishing deeper in the water column than the doors. Pelagic doors are not designed to contact the seafloor. Pelagic trawls are pulled downward by weights attached to the lower wing ends, producing several hundred pounds of downward force. If the trawl is put in firm contact with the seafloor, most of this weight will be supported by the bottom, producing narrow scour tracks. Pelagic trawl footropes used in Alaska are most commonly made of steel chain, with some use of steel cable. Thus, their effects on habitat will have more similarity to tickler chains or small-diameter trawl footropes than to the large-diameter, bobbin-protected, footropes used in Alaska bottom trawls. Small footrope diameter will reduce the height that sediments are suspended into the water column, but make penetration of the sediment when bumps and ridges are encountered more likely. Animals anchored on or in the substrate would be vulnerable to damage or uprooting by this type of footrope. The very large mesh openings in the bottom panels of these trawls make it very unlikely that animals not actively swimming upward in reaction to the net will be retained and hence removed from the seafloor, though they may be displaced a short distance or damaged in place.

In summary, pelagic trawls may be fished in contact with the seafloor, and there are times and places where there may be strong incentives to do so, for example, the EBS shelf during the summer. No data are available to estimate the frequency of this practice. Potential impacts would depend on the vulnerability of epibenthic animals in sand or mud substrates to contact with the small-diameter footropes. Prohibition of footrope protection makes the use, and hence impact, of such gear on hard or rugged substrates unlikely.

3.4.3.2.3 Scallop Dredges

The magnitude and extent of seabed disturbances by scallop fishing vary according to the gear used and the habitats that are fished. For example, Drew and Larsen (1994) conducted a worldwide trawl and dredge study for the submarine cable industry to determine the depths to which various fishing gears penetrate the seabed. For normal fishing conditions, maximum cutting depths ranged from 40 mm for a New Bedford style dredge on sandy/rocky bottom to 300 mm for a mechanized (hydraulic) dredge on softer bottoms. Scallop dredges as a class penetrated less (40 to 150 mm) than beam trawls (60 to 300 mm) and bottom (otter) trawls and doors (50 to 300 mm). Box dredges that are used in shallow water European and Australian bivalve fisheries, some with toothed cutting bars, penetrated up to 250 mm. Overall, lower values were associated with light gear and hard bottoms, while higher values resulted from heavier gears and softer bottoms. Even within a particular gear class, such as scallop dredges, there may be substantial differences in effects. For example, damage to noncaptured scallops is reported to be significantly higher on rock substrate as compared to sand, perhaps due to crushing action of the dredge (Murawski and Serchuk 1989, Messiah et al. 1991, Shepard and Auster 1991). Moreover, a panel of experts recently concluded that much of the scientific literature on benthic habitat effects is based on the European style dredge, which differs in structure and use from the New Bedford style dredge (NREFHSC 2002). The leading edge of the European dredge contains teeth which dig into the substrate. This type of gear is used by smaller vessels that cannot tow a non-toothed dredge fast enough (4 to 5 knots) to fish effectively. The panel noted that because of these differences, research using the European dredge was not very relevant to North American scallop fisheries or the habitats in which they are found, and should only be applied in a limited fashion. The fishing configuration is also an important consideration influencing seabed effects. Although spring-loaded scallop dredges used in Ireland may be relatively narrow (75 cm), some vessels tow as many as 14 of these dredges simultaneously (Maguire et al. 2002). For East Coast and most Alaskan scallop fisheries, two 15-foot New Bedford dredges are simultaneously towed from opposites sides of the vessel, effectively doubling the footprint for each tow.

The weathervane scallop fishery in Alaska occurs in limited, but well-defined areas of the GOA and the EBS (Barnhart 2003). Based on an analysis of sediment properties associated with 28,000 individual dredge hauls for the period 1993 to 1997, Turk (2001) concluded that commercially fished beds occur most frequently on sand and sandy-silt in the GOA. Limited effort occurred in silty-clay substrates and in areas where bedrock and gravelly mud occurred, but was relatively high in sand, sandy to muddy gravel, gravelly sand, and clayey silt to silt substrates. These same data indicate commercial aggregations of scallops in the GOA occur over fairly narrow depth ranges from 25 to 195 m. The overall broad depth range was attributed to additional physical factors that were not investigated. Barnhart (2003) reports the majority of fishing effort for all of Alaska occurs at 40 to 60 fathoms (73 to 110 m). Although there are some areas or portions of areas that contain rock (e.g., Alaska Peninsula Registration Area), the Alaska scallop fishery occurs primarily on soft-bottom areas because fishers avoid harder areas if possible, because of probable damage to their fishing gear (Barnhart, J., May 1, 2003, Alaska Department of Fish and Game, Kodiak, personal communication).

Because the degree of benthic habitat disturbance depends on the gear type used and the composition of the sediment (Watling et al. 2001), only selected studies from the worldwide literature are directly relevant to the Alaska weathervane scallop fishery. Specifically, coverage is limited to studies involving standard New Bedford style dredges (or equivalents) fished without rock chains in relatively soft-bottom areas. As such, scientific studies involving European dredges are excluded because of significant differences in the design and use of this gear. For example, in the early 1980s, 2-foot to 2.5-foot-wide, Newhaven-style, spring-toothed dredges, whose teeth give when obstacles are encountered (thus reducing damage), became more or less universal in the British Isles (Brand 2000). Some controlled studies in sandy areas are also considered to be irrelevant because of the dredge type used (e.g., 1.2-m dredge with fixed teeth measuring 12 cm long and 1 cm wide; Eleftheriou and Robertson 1992). Even Hughes et al. (1977, 1979) studies examining possible short-term environmental effects of the surf clam (*Spisula* now *Mactromeris polynyma*) fishery in the EBS are not considered because of the hydraulic-jet gear type involved. Many New England and mid-Atlantic sea scallop (*Placopecten magellanicus*) studies based on the New Bedford style dredge are also excluded because the coarser shell-gravel-rock substrates preferred by Atlantic sea scallops (Packer et al. 1999; and many other scallop species) are distinctly different from those for weathervane scallops (Turk 2001; Rosenkranz, G., April 25, 2003, personal communication, Alaska Department of Fish and Game, Kodiak). This is because characteristics of physical disturbance and the nature of benthic communities are strongly related to bottom type (NRC 2002).

Scallop dredges are designed to disturb the seabed in order to dislodge and capture scallops (NRC 2002). The following summaries of scientific research detail physical effects on the seafloor and effects on living substrate such as benthic invertebrates. Generally, these studies discuss changes that occur as a result of scallop dredging, but do not interpret the ecological consequences of these changes.

<u>Physical effects</u>: Sediment plumes generated by scallop dredging may cause burial, clog respiratory surfaces, and reduce light levels; they may also release heavy metals, nutrients, or toxic algal cysts (Black and Parry 1999). The magnitude and spatial extent of the suspended sediment field around any dredging operation are a function of the type of dredge used, the physical/biotic characteristics of the material being dredged (e.g., density, grain size, organic content), and site-specific hydrological conditions (e.g., currents, water body size/configuration). The rate of change of plume characteristics depends critically on suspended sediment grain sizes, current strength, and the related water column turbulence (Black and Parry 1999).

<u>Biological effects</u>: At least some of these reported effects can be considered unintentional bycatch by dredges that have inherently poor selection characteristics (Bourne 1966). Overall, dredge impact studies

that are relevant to the Alaska fishery and environments, particularly those with a biological focus, are very limited. Similarly, although offshore scallop dredging has occurred on the sandy Scotian Shelf off eastern Canada since 1862, the thorough review by Messiah et al. (1991) of trawl and dredging impact literature did not include a single study from this area. Although there are obvious differences in the nature of trawls and scallop dredges, it is nevertheless reasonable under the circumstances to consider the results of bottom trawl studies in softer sediments, including sand, as representative of the effects due to scallop dredging. In fact, dredge and trawl studies summarized in major reviews of the literature are frequently handled in this fashion (e.g., Auster and Langton 1999, NRC 2002).

A side-scan sonar survey of Stellwagen Bank in the southwestern Gulf of Maine revealed that scallop dredges disturbed storm sand ripples of coarse sand that measured 30 to 60 cm between crests and 10 to 20 cm in height (Auster et al. 1996). Although the authors believed that strong northeast storms were the primary cause of bottom disturbance in this area, disturbances by mobile fishing gear occurred more regularly. Although benthic sediment features reform rapidly by natural processes, Auster et al. (1996) expressed concern that the temporary but frequent losses of microhabitat could have important ecological consequences.

Currie and Parry (1996) studied dredge impacts using a BACI-experimental design in two adjacent 600- by 600-m, soft-sediment plots in 12 to 15 m of water located 2 km offshore of southeastern Australia. "Peninsula" dredges were fished in a manner and with an intensity consistent with moderately high effort for the fishery in this area (i.e., two passes). These dredges are 2.7 to 3.3 m wide and consist of a cage 1.2 m long and 0.3 m high, which sits on two 70-mm-high skids projecting 0.5 to 0.6 m forward of the cage (Black and Parry 1999). They are fitted with scraper/cutter bars that, in this study, did not extend below the level of the skids. The dredges typically disturbed the top 20 mm of sediment but could penetrate as much as 60 mm. Cone-shaped callianassid shrimp mounds averaging 42 mm high and 152 mm in diameter (maximum 100 mm by 230 mm) were leveled and adjacent pits and depressions were filled. These bedforms were regenerated 1 to 6 months later, with scallops and detached weed present once again in the depressions. Infaunal organisms resided in the top 5 (68 percent) to 10 cm (91 percent) of sediment. Overall, the abundance of 7 of the 10 most common species changed significantly after dredging; 6 species decreased in abundance, while 1 species increased. Some species were cut and killed by the dredges, while others may have been affected by high turbidity, high rates of sedimentation, or by being buried when depressions were filled. Turbidity immediately behind dredges was two to three orders of magnitude greater than occurs during storms (Black and Parry 1994). For typical currents of 0.1 m/s, suspended concentrations above natural levels were confined to a region approximately 54 m from the dredge. The size and persistence of dredging impacts varied between species, but most species decreased in abundance by 20 to 30 percent. Dredging impacts became undetectable for most species following their next recruitment 6 to 14 months later. Changes to community structure caused by dredging were smaller than those that occurred between seasons and years. The maximum impacts did not occur immediately after dredging.

In a subsequent study, Black and Parry (1999) again used Peninsula dredges at multiple large sites in a semi-enclosed tidal embayment and characterized dredge sediment plume characteristics with numerical modeling. They found that the sediment plume accompanied the entire width of the dredge, mostly by the 45° cutter bar, which extended to the level of the skids. As the dredge traveled across irregular bottom, high regions were trimmed off, creating a series of billowing, turbulent pulses of sediment. Otherwise the cutter bar only skimmed the surface. Smaller sediment plumes billowed from both skids and reached higher in the water column than from the cutterbar. Maximum penetration of the dredge was 20 to 60 mm. Grain size distributions in the water column were similar to those on the seabed, indicating that all fractions were entrained together. Settlement rates were a function of grain size, which may result in winnowing of fines if currents are present, producing fundamental changes in benthic habitat characteristics.

Dupaul et al. (1996) investigated unintentional bycatch in scallop fisheries. Overall, Dupaul et al. (1996) characterized the scallop dredges used in the United States, eastern Canada, and Alaskan scallop fisheries as "large, heavy, and unforgiving as a fishing gear with relatively poor species-specific and size selectivity." In addition to finfish and undersized scallop bycatch, quantities of bottom debris and substrate are often retained in the dredge bag along with bottom dwelling invertebrates. NMFS data for the period 1991 to 1993 indicate more than 23,000 mt of finfish and invertebrates were landed as bycatch by the United States scallop dredge fishery. The bycatch of crustaceans and other invertebrates by scallop dredges has been documented for the Alaskan scallop fishery, but little has been done elsewhere. According to NMFS (1998), bycatch of crab in the Alaska scallop dredge fishery is limited by area-specific crab bycatch limits and area closures. Fishery observer data are used to estimate crab bycatch. When the bycatch limits are reached in an area, it is closed to fishing for scallops. Observer data do not suggest that significant bycatch of other commercial species occurs in the scallop fishery. Retention rates may increase in areas with substantial quantities of shells, sand dollars, sea stars, and crabs. Potential solutions to scallop dredge bycatch include increasing dredge ring sizes, reducing chafing gear, modifications in dredge design, changes in fishing strategies, and educational programs for the fishermen. However, collateral damage to discards resulting from the handling of the scallop dredge, culling, and deck operations can exceed 10 percent.

Mayer et al. (1991) examined the effects of a New Bedford-style, chain-sweep, scallop dredge on a poorly sorted mixed shell hash and mud substrate in a shallow (8-m) channel among some coastal islands in mid-coastal Maine. There was evidence of natural winnowing by tidal currents at the undragged control site. Some of the surficial organic matter was exported from the drag site, and the remaining material was mixed into subsurface sediments. Such burial of labile organic matter (phytopigments and proteins) may shift sediment metabolism toward microbial and anaerobic food chains. Phospholipid analysis indicated decreases in various classes of microbiota, with relative increases in the contribution of anaerobic bacteria to the microbial community.

Murawski and Serchuk (1989) used submersible vehicles in the Mid-Atlantic region off the northeast United States to observe general environmental effects of a typical New Bedford dredge. The scallop grounds there have a relatively smooth bottom composed of sand or mud and some shell hash that is generally devoid of rocks and cobbles. They observed very high dredge efficiency with very low (less than 5 percent) dredge-related damage and mortality of uncaught scallops. They noted relatively few potential fish or invertebrate predators capable of feeding on damaged scallops. A comparison of pre-dredging and post-dredging sites from a fine-grained sand and silt (with some 1- to 2-cm shell hash) area off Long Island, New York, revealed the following after dredging: disruption of an aggregation of seven sand dollars, greater quantities of shell hash, and whitish tracks contrasting with darker surrounding areas. Subsequent observations of sand dollar movements indicated that a large fraction of sand dollars survive the dredging process.

Watling et al. (2001) investigated the impact of 23 drags with a 2-m-wide, New Bedford-style scallop dredge on the fauna and sedimentary nutritional characteristics of a silty sand community at 15 m depth. The site, in the Damariscotta River, Maine, was sampled repeatedly before and after dredging. Loss of surficial sediment, lowered food quality of the sediment (as measured by microbial populations, enzyme hydrolysable amino acids, and chlorophyll a), and changes in the faunal composition of the dragged site were observed. While some taxa returned to the drag track relatively quickly, others such as the cumaceans, phoxocephalid and photid amphipods, and nephtyid polychaetes were not seen in abundances comparable to those of the adjacent undragged site until the food quality also recovered.

3.4.3.2.4 Longline Gear

Very little information exists regarding the effects of longlining on benthic habitat, and published literature is essentially nonexistent.

Observers on hook and line vessels have recorded bycatch of HAPC biota. Bycatches of benthic epifauna by Pacific cod fisheries using longline gear off Alaska were comparable to those using trawl gear (NMFS 2000c). Bycatches of anemones and seawhips/pens were higher for longlines than trawls, while trawl bycatches were higher for corals and sponges. On a regional scale, these removals do not represent a large portion of the population. For example, anemone abundance on the EBS shelf, likely underestimated due to the sampling trawl not catching 100 percent of anemones in the trawl path, was estimated at 26,570,000 kg (McConnaughey, B., unpublished data) of which the 3-year (1997 to 1999) longline bycatch of 86,063 kg was at most 0.3 percent. A similar estimate for the Aleutian Islands area, where more of the hard substrates favored by anemones are available, could not be included because the trawl used for those surveys retains very few of the anemones in its path.

Observations of halibut gear made by NMFS scientists during submersible dives studying other aspects of longline gear off southeast Alaska provide some information on potential ways that longlines can affect bottom habitats (High 1998). The following is a summary of these observations:

> Setline gear often lies slack and meanders considerably along the bottom. During the retrieval process, the line sweeps the bottom for considerable distances before ascending. It snags on objects in its path, including rocks and corals. Smaller rocks are upended, hard corals are broken, and soft corals appear unaffected by the passing line. Invertebrates and other lightweight objects are dislodged and pass over or under the line. Fish, notably halibut, frequently moved the groundline numerous feet along the bottom and up into the water column during escape runs, disturbing objects in their path. This line motion was noted for distances of 50 feet or more on either side of the hooked fish.

In addition to the High's (1998) observations, Sigler and Lunsford (2001) cite observations by K.J. Kreiger of small *Primnoa* colonies attached to less than 0.4-m-diameter boulders that had been tipped and dragged, which he attributed to longline gear.

These submersible observations only demonstrate the potential, and some mechanisms for, effects of longlines on benthic habitat, particularly structure-forming animals. Those observations are insufficient to assess whether habitats are significantly altered at either local or regional levels or whether they vary in fisheries that use different gear or methods (i.e., setting mainline under tension). Important missing information includes the area of seafloor affected by longlines, the proportion of animals in that area that are affected, the severity of effects, rates of recovery, and the importance of affected structures in the function of EFH.

3.4.3.2.5 Pot Gear

Pots are considered to be less damaging than mobile gear, because they are stationary in nature, and thus, come into direct contact with a much smaller area of the seafloor. Pots affect habitat when they settle to the bottom and when they are hauled back to the surface (Eno et al. 2001, Stewart 1999), but single pots and pots longliner together may also affect seafloor habitat when they are pulled along the seafloor. This would occur in steeper terrain when wind and tide conditions dictated that gear be pulled upslope rather than to open water.

Physical damage from pots is highly dependent on habitat type. Sand and soft sediments are less likely to be affected, whereas reef-building corals, sponges, and gorgonians are more likely to be damaged because of their three-dimensional structure above the seafloor (Quandt 1999). Damage by pots also makes coral more susceptible to secondary infections. In south Florida, Sutherland et al. (1983) completed a submersible survey of derelict pots following the closure of the pot fishery in the state. Pots were set either singly or in lines, and most were set within 20 to 45 m of a coral reef and rock ledge. Of 23 derelict/ghost traps, 15 were on sand or algal flats, 4 were on high profile reef, and 4 were in live-bottom area.

Eno et al. (2001) observed effects of pots set in water depths from approximately 14 to 23 m over a wide range of sediment types in Great Britain, including mud communities with sea pens, limestone slabs covered by sediment, large boulders interspersed with coarse sediment, and rock. Observations demonstrated that sea pens were able to recover fully from pot impact (left in place for 24 to 48 hours) within 72 to 144 hours of the pots being removed. Pots remained stationary on the seafloor, except in cases where insufficient line and large swells caused pots to bounce off the bottom. When pots were hauled back along the bottom, a track was left in the sediments, but abundances of organisms within that track were not affected. The authors did observe detached ascidians and sponges and damage to rose coral, but it was not clear if these resulted from this study or from previous damage. Authors concluded that no short-term effects result from the use of pots, even for sensitive species. The study did not examine chronic effects.

The pots used off Alaska are much larger and heavier than those in any of the studies cited. Except in the Aleutians and certain months in the EBS, Alaska groundfish regulations require that each pot have its own buoyed line, so there are no underwater lines connecting adjacent pots (longlining) which could be an additional source of effects. Little research has been conducted to date on their habitat effects. The area of seafloor contacted by each pot during retrieval is unknown and is expected to depend on vessel operations, weather, and current.

However, there is some evidence from submersible video transects conducted in the central AI that damage sustained to dense areas of coral and sponge habitat may have been caused by crab pots in contact with that habitat (Robert Stone, NOAA Fisheries). Scientists observed elongated tracks where sessile epifuana had been removed or pushed and piled aside. Tracks were well delineated, straight, and about 3 m wide. Tracks did not appear to be consistent with damage observed from longlines or bottom trawl gear, nor that expected from submersible contact with the seafloor or landslides. There is still some uncertainty as to whether pot fishing was responsible for the damage, and the researchers are planning, pending the availability of research funds, to drag longlines of pots through the area to determine if they can replicate such tracks.

A large number of pots are lost in Alaska fisheries every year. Although pots might be considered less damaging to habitat than mobile gear, lost pots can have effects on populations of fish and crustaceans. Bullimore et al. (2001) observed traps left out off the coast of Wales for 398 days and reported that lost pots continued to collect fish for as long as they were left out, even though the bait was gone after 13 to 27 days. Derelict pots add vertical structure that is frequently colonized by sedentary invertebrates, altering the local environment. Alaska pot fisheries must install untreated cotton twine in pot walls to eventually stop ghost fishing.

3.4.4 Non-fishing Activities That May Affect Fish Habitat

Offshore of Alaska, management plans regulate fishery harvest; however, continual adverse human impacts, including non-fishing and fishing activities and natural disturbances, likely have contributed to the depletion of some fishery resources and associated biological, chemical, and physical environmental conditions. Section 305(b)(1) of the Magnuson-Stevens Act requires the Secretary of Commerce to coordinate with, and provide information to, other federal agencies regarding the conservation and enhancement of EFH. Section 305(b)(2) requires all federal agencies to consult with the Secretary on all actions or proposed actions authorized, funded, or undertaken by the agency that may adversely affect EFH. NMFS has defined five approaches to meet the EFH consultation requirements: use of existing procedures, general concurrences, programmatic consultations, abbreviated consultations, and expanded consultations. Further information on the consultation process is available on the Alaska Region's website.

An adverse effect, as defined at 50 CFR 600.810, means any impact that reduces the quality and/or quantity of EFH. A reduction of quality and/or quantity of EFH can be caused by human actions, either associated with fishing or not, or by natural actions. Reductions in quality and/or quantity may be site-specific or habitat-wide and can result from the individual, cumulative, or synergistic consequences of actions. A direct impact to a defined EFH will result in loss of its ability to provide specific habitat for a species. Cumulative impacts are linked to the quantity and location of impacts within a given geographic location. For purposes of this analysis, cumulative impacts are those impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions. Impacts like these can build on one another, especially in developed areas or communities. Equally important are natural adverse effects such as storm damage or climate-based environmental shifts that can contribute to the loss of EFH. Loss of EFH, which is defined at 50 CFR 600.10 to mean waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity, will reduce the species' ability to reproduce, survive, or exist (Council 1999a).

Species dependent on coastal areas during various stages of their lives, particularly during juvenile rearing and adult reproduction, are more vulnerable to habitat alterations than are species that remain offshore. Also, the effects of habitat alteration on offshore species are not as apparent as they are in coastal areas. Concern is warranted, however, to the degree that 1) the offshore environment is subject to habitat degradation from either inshore activities or offshore uses and 2) some species living offshore depend directly or indirectly on coastal habitats for a critical life stage such as reproduction or as a source of food (Council 1999a).

Appendix G of the EFH SEIS discusses types of activities that have a potential to cause habitat degradation that could affect fishery populations. This discussion is a collaborative effort among NMFS' Alaska Region, Northwest Region, and Southwest Region and is a broad overview designed to identify those activities that may reasonably be expected to adversely affect EFH. This cooperative task was undertaken in an effort to provide an exchange of information and to promote consistency in NMFS consultation and commenting activities.

To assist with these consultation and commenting activities, Appendix G addresses those activities most likely to reduce the quantity and/or quality of EFH. It is not meant to provide a conclusive review and analysis of the impacts of all potentially detrimental activities; rather, it highlights notable threats and provides information to determine if further examination of a proposed activity is necessary. Whether the likelihood and level of these activities or events cause harm to species' habitats can be decided when the details of a proposed activity's location, magnitude, timing, and duration are better known. This section also suggests in an advisory, not mandatory, capacity proactive conservation measures that would help minimize and avoid adverse effects of these non-fishing activities on EFH.

Potential impacts from non-fishing activities are monitored during the NMFS and state of Alaska permit review process, and development of habitat computer databases and GIS location maps has greatly assisted that effort. Some of the activities discussed in Appendix G may not be applicable to Alaska, either due to geographic location or because the industry associated with the impact does not occur in Alaska. An example would be adverse effects resulting from agricultural runoff associated with a "milking parlor." It would be improbable that such an activity would occur in a geographic region such as the AI or the EBS. Table 3.4-36 is a professional interpretive summary of those threats identified in Appendix G as they relate to the Alaska Region, and Table 3.4-37 is a summary of the effects determination of those threats, also based on professional interpretation.

3.5 Regulatory Environment

The following sections summarize major laws and regulations directly applicable to this action. Other relative laws and requirements (e.g., Executive Order [EO] for Federalism, Marine Protected Areas) will be addressed elsewhere in the Record of Decision and/or in the classification section of the proposed and final rule.

3.5.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 is legislation signed into law in response to an overwhelming national sentiment that federal agencies should take the lead in providing greater protection for the environment. It established environmental policy for the nation, provided an interdisciplinary framework for federal agencies, and established procedures and a public process to ensure that federal agency decisionmakers take environmental factors into account. The analysis prepared for the federal decisionmaker is typically an environmental assessment (EA) or an EIS.

NEPA requires an EA to determine whether the action considered will result in significant impact on the human environment. If the action is determined not to be significant based on an analysis of relevant considerations, the EA and resulting finding of no significant impact (FONSI) would be the final environmental documents required by NEPA.

An EIS must be prepared for major federal actions significantly affecting the human environment. As stated in 40 CFR 1502.9(c):

> Agencies shall prepare supplements to either draft or final environmental impact statements if: (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or (ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.

3.5.2 Magnuson-Stevens Fishery Conservation and Management Act

In 1976, Congress passed into law what is currently known as the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). This law authorized the United States to manage its fishery resources in an area extending from 3 to 200 nm (4.8 to 320 km) off its coast, referred to as the EEZ. The management of these marine resources is vested in the Secretary and in regional fishery management councils (FMCs). In the Alaska region, the Council is responsible for preparing FMPs for marine fishery resources requiring conservation and management. These FMPs are submitted for approval and implementation by the Secretary, through NMFS, an agency within NOAA and the United States Department of Commerce. Specifically, NMFS's Alaska Regional Office and AFSC research, draft, and review the management actions recommended by the Council.

The Magnuson-Stevens Act established a set of national standards for fishery conservation and management. For example, each FMP must specify the optimum yield from each fishery that would provide the greatest benefit to the United States and must state how much of that optimum yield can be expected to be harvested in United States waters. FMPs must also specify the level of fishing that would constitute overfishing. In addition, each FMP contains a suite of additional management tools that together characterize the fishery management regime. These management tools are either a framework type measure, thereby allowing for annual or periodic adjustment using a streamlined notice process, or are conventional measures that are fixed in the FMP and its implementing regulations and require a formal plan or regulatory amendment to change. Amendments to the FMP or its regulations are considered annually by the Council, with proposed amendments submitted by both the resource agencies and the public. As a result, the FMPs are dynamic and are continuously changing as new information or problems arise.

National Standards of the Magnuson-Stevens Fishery Conservation and Management Act.

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.

2. Conservation and management measures shall be based upon the best scientific information available.

3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (a) fair and equitable to all such fishermen, (b) reasonably calculated to promote conservation, and (c) carried out in such a manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

5. Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

7. Conservation and management shall, where practicable, minimize costs and avoid unnecessary duplication.

8. Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (a) provide for the sustained participation of such communities, and (b) to the extent practicable, minimize adverse economic impacts on such communities.

9. Conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

10. Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

3.5.3 Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA), first enacted in 1980, was designed to place the burden on the government to review all regulations to ensure that, while accomplishing their intended purposes, they do not unduly inhibit the ability of small entities to compete. The RFA recognizes that the size of a business, unit of government, or nonprofit organization frequently has a bearing on its ability to comply with a federal regulation. Major goals of the RFA are 1) to increase agencies' awareness and understanding of the impact of their regulations on small business, 2) to require that agencies communicate and explain their findings to the public, and 3) to encourage agencies to use flexibility and to provide regulatory relief to small entities. The RFA emphasizes predicting impacts on small entities as a group distinct from other entities and on the consideration of alternatives that may minimize the impacts while still achieving the stated objective of the action. The RFA recognizes and defines three kinds of small entities: 1) small businesses, 2) small non-profit organizations, and 3) and small government jurisdictions.

The objective of the RFA is to require consideration of the capacity of those affected by regulations to bear the direct and indirect costs of regulation. If an action will have a significant impact on a substantial number of small entities, an Initial Regulatory Flexibility Analysis (IRFA) must be prepared to identify the need for the action, alternatives, potential costs and benefits of the action, distribution of these impacts, and determination of net benefits. The central focus of the IRFA should be on the economic impacts of a regulation on small entities and on the alternatives that might minimize the impacts and still accomplish the statutory objectives. The level of detail and sophistication of the analysis should reflect the significance of the impact on small entities. An IRFA for this action is included with this analysis in Appendix C.

3.5.4 Executive Order 12866

The requirements for all regulatory actions specified in EO 12866 are summarized in the following statement from the order:

> In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environment, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach.

EO 12866 and the RFA require a determination of whether an action is significant under EO 12866 or will result in significant impacts on small entities under the RFA. This determination is found in an RIR. An RIR is included with this analysis in Appendix C. EO 12866 requires that the Office of Management and Budget (OMB) review proposed regulatory programs that are considered to be significant.

3.5.5 Coordination with Others

The Council on Environmental Quality (CEQ) regulations for implementing the procedural provisions of NEPA emphasize agency cooperation early in the NEPA process. 40 CFR section 1501.6 states the following: "Upon request of the lead agency, any other federal agency which has jurisdiction by law shall be a cooperating agency. In addition, any other federal agency which has special expertise with respect to any environmental issue, which should be addressed in the statement, may be a cooperating agency upon request of the lead agency."

NMFS requested that the United States Coast Guard (USCG), the United States Department of the Interior's USFWS, and ADF&G be cooperating agencies in preparing this draft EIS. Each agency agreed to participate in its development and provided data, staff, and review for this analysis. In addition, NMFS requested that the Council staff assist in organizing, writing, and preparing the analysis. Along with staff preparers of the lead agency, individuals from cooperating agencies, Council staff, and consulting agencies hired by the lead agency contributed to this analysis and are listed in Section 5.0, List of Preparers.

Both USFWS and USCG have non-voting seats on the Council. USFWS has trust authority for seabird and other avian species in the management areas and has provided guidance for understanding and managing seabird and fishery interactions. Expert USFWS staff serve on the Council Groundfish Plan Teams. USCG has expertise with enforcement, search and rescue, vessel accidents and incidents at sea, and human safety at sea. USCG staff provided skilled assistance for this analysis.

The Environmental Protection Agency (EPA) is a reviewing agency for all EISs. This draft EIS will be filed with EPA for publication and public review.

Representatives from the states of Alaska, Washington, and Oregon have voting seats on the Council. ADF&G experts provided assistance with this analysis.

3.5.6 Magnuson-Stevens Act Provisions and Regulations for EFH

Under 16 U.S.C. 1853(a), "Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, shall . . . (7) describe and identify EFH for the fishery based on guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat" (Magnuson-Stevens Act, Section 303[a][7]).

Section 305(b) of the Magnuson-Stevens Act provides further guidance on the need to describe and protect EFH and the establishment of guidelines by the Secretary. On January 17, 2002, NMFS published a final rule (67 FR 2343), effective on February 19, 2002, which provides the guidelines specified in Section 303(a)(7) of the Magnuson-Stevens Act. The following provisions, found at 50 CFR section 600.815, were intended to assist the Council in its task to designate and protect EFH.

(a) Mandatory contents–

(1) Description and identification of EFH

(i) <u>Overview</u>. FMPs must describe and identify EFH in text that clearly states the habitats or habitat types determined to be EFH for each life stage of the managed species. FMPs should explain the physical, biological, and chemical characteristics of EFH and, if known, how these characteristics influence the use of EFH by the species/life stage. FMPs must identify the specific geographic location or extent of habitats described as EFH. FMPs must include maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found.

(ii) <u>Habitat information by life stage</u>.

(A) Councils need basic information to understand the usage of various habitats by each managed species. Pertinent information includes the geographic range and habitat requirements by life stage, the distribution and characteristics of those habitats, and current and historic stock size as it affects occurrence in available habitats. FMPs should summarize the life history information necessary to understand each species' relationship to, or dependence on, its various habitats, using text, tables, and figures, as appropriate. FMPs should document patterns of temporal and spatial variation in the distribution of each major life stage (defined by developmental and functional shifts) to aid in understanding habitat needs. FMPs should summarize (e.g., in tables) all available information on environmental and habitat variables that control or limit distribution, abundance, reproduction, growth, survival, and productivity of the managed species. The information should be supported with citations.

(B) Councils should obtain information to describe and identify EFH from the best available sources, including peer-reviewed literature, unpublished scientific reports, data files of government resource agencies, fisheries landing reports, and other sources of information. Councils should consider different types of information according to its scientific rigor. FMPs should identify species-specific habitat data gaps and deficits in data quality (including considerations of scale and resolution; relevance; and potential biases in collection and interpretation). FMPs must demonstrate that the best scientific information available was used in the description and identification of EFH, consistent with national standard 2.

(iii) Analysis of habitat information.

(A) The following approach should be used to organize the information necessary to describe and identify EFH.

(1) Level 1: Distribution data are available for some or all portions of the geographic range of the species. At this level, only distribution data are available to describe the geographic range of a species (or life stage). Distribution data may be derived from systematic presence/absence sampling and/or may include information on species and life stages collected opportunistically. In the event that distribution data are available only for portions of the geographic area occupied by a particular life stage of a species, habitat use can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior. Habitat use may also be inferred, if appropriate, based on information on a similar species or another life stage.

(2) Level 2: Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

(3) Level 3: Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life stage).

(4) Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life stage to habitat type, quantity, quality, and location. Essential habitats are those necessary to maintain fish production consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

(B) Councils should strive to describe habitat based on the highest level of detail (i.e., Level 4). If there is no information on a given species or life stage, and habitat usage cannot be inferred from other means, such as information on a similar species or another life stage, EFH should not be designated.

(iv) EFH determination.

(A) Councils should analyze available ecological, environmental, and fisheries information and data relevant to the managed species, the habitat requirements by life stage, and the species' distribution and habitat usage to describe and identify EFH. The information described in paragraphs (a)(1)(ii) and (iii) of this section will allow Councils to assess the relative value of habitats. Councils should interpret this information in a risk-averse fashion to ensure adequate areas are identified as EFH for managed species. Level 1 information, if available, should be used to identify the geographic range of the species at each life stage. If only Level 1 information is available, distribution data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify EFH as those habitat areas most commonly used by the species. Level 2 through 4 information, if available, should be used to identify EFH as the habitats supporting the highest relative abundance; growth, reproduction, or survival rates; and/or production rates within the geographic range of a species. FMPs should explain the analyses conducted to distinguish EFH from all habitats potentially used by a species.

(B) FMPs must describe EFH in text, including reference to the geographic location or extent of EFH using boundaries such as longitude and latitude, isotherms, isobaths, political boundaries, and major landmarks. If there are differences between the descriptions of EFH in text, maps, and tables, the textual description is ultimately determinative of the limits of EFH. Text and tables should explain pertinent physical, chemical, and biological characteristics of EFH for the managed species and explain any variability in habitat usage patterns, but the boundaries of EFH should be static.

(C) If a species is overfished and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species may be considered essential in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible. Once the fishery is no longer considered overfished, the EFH identification should be reviewed and amended, if appropriate.

(D) Areas described as EFH will normally be greater than or equal to aquatic areas that have been identified as "critical habitat" for any managed species listed as threatened or endangered under the ESA.

(E) Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species. EFH must be designated for each managed species, but, where appropriate, may be designated for assemblages of species or life stages that have similar habitat needs and requirements. If grouping species or using species assemblages for the purpose of designating EFH, FMPs must include a justification and scientific rationale. The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that are necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem.

(F) If degraded or inaccessible aquatic habitat has contributed to reduced yields of a species or assemblage and if, in the judgment of the Secretary and the appropriate Council(s), the degraded conditions can be reversed through such actions as improved fish passage techniques (for stream or river blockages), improved water quality measures (removal of contaminants or increasing flows), and similar measures that are technologically and economically feasible, EFH should include those habitats that would be necessary to the species to obtain increased yields.

(v) EFH mapping requirements.

(A) FMPs must include maps that display, within the constraints of available information, the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found. Maps should identify the different types of habitat designated as EFH to the extent possible. Maps should explicitly distinguish EFH from non-EFH areas. Councils should confer with NMFS regarding mapping standards to ensure that maps from different

Councils can be combined and shared efficiently and effectively. Ultimately, data used for mapping should be incorporated into a GIS to facilitate analysis and presentation.

(B) Where the present distribution or stock size of a species or life stage is different from the historical distribution or stock size, then maps of historical habitat boundaries should be included in the FMP, if known.

(C) FMPs should include maps of any habitat areas of particular concern identified under paragraph (a)(8) of this section.

(2) Fishing activities that may adversely affect EFH

(i) Evaluation. Each FMP must contain an evaluation of the potential adverse effects of fishing on EFH designated under the FMP, including effects of each fishing activity regulated under the FMP or other federal FMPs. This evaluation should consider the effects of each fishing activity on each type of habitat found within EFH. FMPs must describe each fishing activity, review and discuss all available relevant information (such as information regarding the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed), and provide conclusions regarding whether and how each fishing activity adversely affects EFH. The evaluation should also consider the cumulative effects of multiple fishing activities on EFH. The evaluation should list any past management actions that minimize potential adverse effects on EFH and describe the benefits of those actions to EFH. The evaluation should give special attention to adverse effects on habitat areas of particular concern and should identify for possible designation as habitat areas of particular concern any EFH that is particularly vulnerable to fishing activities. Additionally, the evaluation should consider the establishment of research closure areas or other measures to evaluate the impacts of fishing activities on EFH. In completing this evaluation, Councils should use the best scientific information available, as well as other appropriate information sources. Councils should consider different types of information according to its scientific rigor.

(ii) Minimizing adverse effects. Each FMP must minimize to the extent practicable adverse effects from fishing on EFH, including EFH designated under other federal FMPs. Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature, based on the evaluation conducted pursuant to paragraph (a)(2)(I) of this section and/or the cumulative impacts analysis conducted pursuant to paragraph (a)(5) of this section. In such cases, FMPs should identify a range of potential new actions that could be taken to address adverse effects on EFH, include an analysis of the practicability of potential new actions, and adopt any new measures that are necessary and practicable. Amendments to the FMP or to its implementing regulations must ensure that the FMP continues to minimize to the extent practicable adverse effects on EFH caused by fishing. FMPs must explain the reasons for the Council's conclusions regarding the past and/or new actions that minimize to the extent practicable the adverse effects of fishing on EFH.

(iii) Practicability. In determining whether it is practicable to minimize an adverse effect from fishing, Councils should consider the nature and extent of the adverse effect on EFH and the long and short-term costs and benefits of potential management measures to EFH, associated fisheries, and the nation, consistent with national standard 7. In determining whether management measures are practicable, Councils are not required to perform a formal cost/benefit analysis.

(iv) Options for managing adverse effects from fishing. Fishery management options may include, but are not limited to:

(A) Fishing equipment restrictions. These options may include, but are not limited to: seasonal and areal restrictions on the use of specified equipment, equipment modifications to allow escapement of particular species or particular life stages (e.g., juveniles), prohibitions on the use of explosives and chemicals, prohibitions on anchoring or setting equipment in sensitive areas, and prohibitions on fishing activities that cause significant damage to EFH.

(B) Time/area closures. These actions may include, but are not limited to: closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life stages, such as those areas designated as habitat areas of particular concern.

(C) Harvest limits. These actions may include, but are not limited to, limits on the take of species that provide structural habitat for other species assemblages or communities and limits on the take of prey species.

(3) Non-Magnuson-Stevens Act fishing activities that may adversely affect EFH. FMPs must identify any fishing activities that are not managed under the Magnuson-Stevens Act that may adversely affect EFH. Such activities may include fishing managed by state agencies or other authorities.

(4) Non-fishing related activities that may adversely affect EFH. FMPs must identify activities other than fishing that may adversely affect EFH. Broad categories of such activities include, but are not limited to: dredging, filling, excavation, mining, impoundment, discharge, water diversions, thermal additions, actions that contribute to non-point source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. For each activity, the FMP should describe known and potential adverse effects to EFH.

(5) Cumulative impacts analysis. Cumulative impacts are impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time. To the extent feasible and practicable, FMPs should analyze how the cumulative impacts of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale. An assessment of the cumulative and synergistic effects of multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts) and an assessment of the ecological risks resulting from the impact of those threats on EFH, also should be included.

(6) Conservation and enhancement. FMPs must identify actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or compensate for the adverse effects identified pursuant to paragraphs (a)(3) through (5) of this section, especially in habitat areas of particular concern.

(7) Prey species. Loss of prey may be an adverse effect on EFH and managed species because the presence of prey makes waters and substrate function as feeding habitat, and the definition of EFH includes waters and substrate necessary to fish for feeding. Therefore, actions that reduce the availability of a major prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat that are known to cause a reduction in the population of the prey species, may be considered adverse effects on EFH if such actions reduce the quality of EFH. FMPs should list the major prey species for the species in the fishery management unit and discuss the location of prey species' habitat. Adverse effects on prey species and their habitats may result from fishing and non-fishing activities.

(8) Identification of habitat areas of particular concern. FMPs should identify specific types or areas of habitat within EFH as habitat areas of particular concern based on one or more of the following considerations:

(i) The importance of the ecological function provided by the habitat.
(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
(iv) The rarity of the habitat type.

(9) Research and information needs. Each FMP should contain recommendations, preferably in priority order, for research efforts that the Councils and NMFS view as necessary to improve upon the description and identification of EFH, the identification of threats to EFH from fishing and other activities, and the development of conservation and enhancement measures for EFH.

(10) Review and revision of EFH components of FMPs. Councils and NMFS should periodically review the EFH provisions of FMPs and revise or amend EFH provisions as warranted based on available information. FMPs should outline the procedures the Council will follow to review and update EFH information. The review of information should include, but not be limited to, evaluating published scientific literature and unpublished scientific reports; soliciting information from interested parties; and searching for previously unavailable or inaccessible data. Councils should report on their review of EFH information as part of the annual SAFE report prepared pursuant to § 600.315(e). A complete review of all EFH information should be conducted as recommended by the Secretary, but at least once every 5 years.

(b) Development of EFH recommendations for Councils

After reviewing the best available scientific information, as well as other appropriate information, and in consultation with the Councils, participants in the fishery, interstate commissions, federal agencies, state agencies, and other interested parties, NMFS will develop written recommendations to assist each Council in the identification of EFH, adverse impacts to EFH, and actions that should be considered to ensure the conservation and enhancement of EFH for each FMP. NMFS will provide such recommendations for the initial incorporation of EFH information into an FMP and for any subsequent modification of the EFH components of an FMP. The NMFS EFH recommendations may be provided either before the Council's development of a draft EFH document or later as a review of a draft EFH document developed by a Council, as appropriate.

(c) Relationship to other fishery management authorities

Councils are encouraged to coordinate with state and interstate fishery management agencies where federal fisheries affect state and interstate managed fisheries or where state or interstate fishery regulations affect the management of federal fisheries. Where a state or interstate fishing activity adversely affects EFH, NMFS will consider that action to be an adverse effect on EFH pursuant to paragraph (a)(3) of this section and will provide EFH Conservation Recommendations to the appropriate state or interstate fishery management agency on that activity.